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WITH ABSTRACT OF THE LITERATURE

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The National Institute of Health of the United States Public Health Service

The Kata-Thermometer as an Anemometer

Rational Method for Calculating Records Obtained by Means of Owens' Jet Dust Counting Apparatus

Coal Miners' Lung: A Radiographic Study of Certain Groups of Industrially Healthy South Wales Coal Miners

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THE JOURNAL OF INDUSTRIAL HYGIENE

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THE NATIONAL INSTITUTE OF HEALTH OF THE UNITED STATES PUBLIC HEALTH SERVICE

H. S. CUMMING, M.D.

Surgeon General

THE importance of scientific research is becoming more and more appreciated in all branches of human activity. Those who are actually engaged in such work may often have cause to feel that their viewpoint is not fully understood, and that their efforts are not so highly valued as they should be. In fact, a few may be reminded of their spiritual kinship with the early pioneers in science who were always misunderstood, usually persecuted, frequently silenced and cast into prison, and sometimes burned at the stake. Nevertheless, the facts are all against the truth of any such assumptions, which may be taken and dismissed as evidences of "temperament."

It is, however, extremely refreshing when a layman, himself not especially conversant with the methods of scientific procedure, nevertheless is sufficiently discerning to appreciate not only the material benefits of acquiring demonstrable knowledge, but the broadening intellectual horizon of mankind which goes along with these benefits. Of course there are the habitual objectors who are wont to look upon all these so-called advances with jaundiced eye. In the advances of chemistry and mechanics they see only increased facilities for destruction and the mechanizing of the individual, and the discoveries of biology are to them subversive of beauty and tradition.

There are even those who discern disadvantages in medical and public health advances, accusing them of patching up inferiors and breeding a race of weaklings, but they have signally failed to make out their case; moreover, as far as can be seen they are quite willing to take advantage for themselves and their families of all the benefits of modern medicine and public health, without bothering to be

classified first as fit or unfit, weakling or strongheart.

These considerations did not annoy or hinder Senator Ransdell when he devised his Bill for the establishment of the National Institute of Health. With plain good sense he saw that research in medicine and public health was a good thing. He had had sufficient observant experience in life to be familiar with many examples of the benefits arising from such research. He knew furthermore that there was not enough of it going on. He was shown through the Hygienic Laboratory of the United States Public Health Service, talked with the scientists at work there, admired the equipment, listened to the story of over a quarter of a century's solid accomplishment, and pronounced it all good. "But," he said, "there is not enough of this good work going on. You have at present many projects and problems for research which you are unable to undertake because of insufficient personnel and funds." From about this time the plan for the Ransdell Act began to take definite shape. Its passage in May, 1930, was not only unopposed but was characterized by the support of a large number of medical, health, and scientific bodies throughout the country.

The purpose of the Ransdell Act is primarily to provide for the continuation of just the sort of work which the Hygienic Laboratory had been carrying on, but, as the Senator said, for much more of it. An institution is envisioned in which the many subjects of science which have medical and public health significance may be brought together, each under an able specialist, to the end that by cooperation and the exchange of ideas the field may be more adequately covered and an impetus given to the advance against disease. The Act makes use of the Hygienic Laboratory as a nucleus for all this future development, and authorizes the appropriation of $750,000 for a new building on the present site of that well-known institution of research. The Parker Act passed in April, 1930, provides for the establishment of additional divisions from time to time as one or another branch of investigation looms up sufficiently important to demand that distinction. The present divisions are four in number: Pathology and Bacteriology, Zoology, Chemistry, and Pharmacology. One can surmise that before many years there will be divisions of physiology, physics, industrial hygiene, and possibly psychology.

A significant feature of the Ransdell Act is the provision for bringing into the organization a group of interested and capable workers by means of the establishment of fellowships. It is contemplated that these will be offered only to scientists who have already demonstrated their fitness to carry out independent investigation. They may, according to the Act, either perform their work under the roof of the Institute at Washington or be assigned to other scientific centers in this country or abroad.

The Act also provides for the extension of the facilities of the Institute to bona fide health workers of the cities, counties, and states for purposes of instruction or study.

Now comes the most interesting subject of funds. Aside from the three-quarters of a million already mentioned and the continuation of the

annual appropriations for the personnel and maintenance of the Hygienic Laboratory (now National Institute of Health) which Congress may be expected to provide, the Ransdell Act apparently contemplates no support of the project from government funds. Instead of this the Act provides that gifts by will or otherwise may be accepted by the Secretary of the Treasury on behalf of the United States to be applied to the purposes which have been discussed. This may include the acquisition of land, the erection of buildings, the provision of equipment, and the establishment of fellowships.

Gifts may be made unconditionally, that is, to be applied wherever in the program of research they will, in the opinion of the Secretary and his advisers, do the most good; or, subject to approval by the same authority, they may be applied for specific purposes. Gifts of $500,000 or more are to be suitably commemorated by memorials in the Institute.

Persons who are so blessed with financial resources that they are in a position to make investments on behalf of the welfare of humanity will search for a long time before they will find a more promising field than is offered by the National Institute of Health. In the first place this is no visionary scheme to make something out of nothing. The Institute is already a going concern. It has excellent buildings modernly equipped and manned by a scientific personnel of proved competence. Its contributions in the past (as the Hygienic Laboratory) have been first class, sound, and, what is by no means universal in research work, durable.

Briefly, the advantages which the National Institute of Health offers as an investment in health, and consequently in happiness and prosperity, are as follows: (1) The objects are good beyond all controversy. (2) The means, scientific research, are generally accepted as the hope of the future, near and remote. (3) The auspices, the federal government, give the best promise of continuity and permanence which man can devise. (4) Under government machinery the danger of wastage and misuse of funds is reduced to a minimum. (5) The Institute is a continuation and expansion of the Hygienic Laboratory which for many years has maintained a reputation of the highest order for scientific research in public health subjects. Approximately 120 scientists and assistants are at work there daily. (6) By means of its publications and contacts the United States Public Health Service is in a position to bring the results of this research to the attention of health officials and sanitarians throughout the country and in fact throughout the world, so that mankind may profit by their application.

THE KATA-THERMOMETER AS AN ANEMOMETER*

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From the Industrial Health Research Board, London

VARIOUS papers dealing with the kata-thermometer have appeared in This Journal. In that by Hill, Angus, and Newbold (1) the measure of agreement between the various equations relating cooling power with temperature and air velocity is discussed, and the various equations which have been advanced are set out.

The close measure of agreement reached by the various observers is evidence of the considerable accuracy with which the air velocity can be determined from readings of the dry kata. Nevertheless, we thought it desirable that the reliability of air velocities calculated from kata readings should be demonstrated in unidirectional currents by means of some direct visual or olfactory test. The observations to be described were made at two collieries; one (Colliery A) was a safety lamp pit where the temperature ranged from 73° to 80°F., and the other (Colliery B) a small, naked light colliery, where the air temperature was about 50° at the time of our visit.

Smell Test

A measured distance, which varied from 10 to 50 feet according to the strength of the air current, was marked off where the velocity was to be determined, and an observer was stationed at either end. By means of a small blowpipe atomizer the observer at the intake side projected a puff of strong ammonia at right angles to the direction of the air current, and the other observer started a stop watch at that instant. When this second observer detected the smell of ammonia, he stopped his watch and the time was noted. Several observations were made at each place. In some cases widely divergent times were noted. This was apparently due to variations in the concentration of the ammonia vapor across the section of the airway. If the second observer happened to be where the concentration was light, he was not able to detect the smell immediately the vapor reached him. For this reason the air velocity has been calculated from the observation giving the fastest time. Observations of temperature and cooling power were made in the middle of the measured distance.

In Table 1 we have shown the velocities as determined by the smell test, and, for comparison, the velocities calculated from the various dry kata equations. On the right of the table we have shown the extent to which the velocities calculated from the dry kata readings vary from those

*Received for publication Aug. 27, 1930.

obtained by means of the smell test. The data obtained at the two collieries have been recorded separately so as to show any effect of differences of temperature.

Following are the various equations for the dry kata, under the same reference numbers as those used in the table:

Hill, Vernon, and Hargood-Ash (2):

$$\frac{H}{\theta} = 0.13 + 0.47 \sqrt{v} \qquad (1)$$

for velocities of 1 to 17 meters per second;

$$\frac{H}{\theta} = 0.20 + 0.40 \sqrt{v} \qquad (2)$$

for velocities below 1 meter per second.

Weiss (cited in (1)):

$$\frac{H}{\theta} = 0.49 \sqrt{v} + 0.14 \qquad (3)$$

for velocities from 0.163 to 9.05 meters per second.

Bradtke (cited in (1)):

$$\frac{H}{\theta^{1.06}} = 0.403 \sqrt{v} + 0.10 \qquad (4)$$

Hill, Angus, and Newbold (1):

$$\frac{H}{\theta} = 0.50803 \sqrt{v} + 0.10551 \qquad (5)$$

The notation in each case is:

H = dry kata cooling power
θ = difference between 36.5 and dry bulb temperature in degrees centigrade
v = air velocity in meters per second

Vernon's temperature corrections for equations 1 and 2 may be found in (3).

Considering first the data from Colliery A, where the temperature averaged 77°, we see that at velocities of 200 feet per minute or more, the average velocity obtained by equation 1 was exactly the same as the average obtained by the smell test, and the same equation gave a very similar average value when Vernon's corrections were applied. Equation 4 gave rather high values and equation 5 rather low, but they both agreed about equally well with the average for the smell test. Equation 3 gave distinctly lower values. At velocities between 100 and 200 feet per minute, equation 5 gave the best average result, equation 2 being very close to it. In the lowest velocity group, equation 5 was not applicable, but equation 3 could be used for all except one value. It will be seen that equation 2 gave a much better average result when Vernon's corrections were applied than when it was used alone. The best fit in this low velocity group was given by equation 3, for the average velocity given by the equation was 43 feet per minute, as compared with an average of 41 feet from the corresponding smell tests.

When we compare the variability of the individual observations from the corresponding smell test values, we find similar results. Taking all observations at 60 feet per minute or over, the lower limit of the range of equation 5, the mean percentage variation is much the same, varying only from 11 to 13 per cent. Below this range the best results are given by equation 3, and are closely approached in consistency by those given by equation 2 with Vernon's corrections applied. We have not seen Bradtke's paper, and do not know for what range of velocity his equation is valid, but at these lower velocities it gives values which are definitely too high.

In the observations made at Colliery B, with an average temperature of 51°, the best results were given by equations 1 and 2, using Vernon's corrections. The mean variability of velocities calculated from these equations from those given by the small test

TABLE 1.—COMPARISON OF AIR VELOCITIES DETERMINED BY SMELL TEST WITH THOSE CALCULATED FROM KATA-THERMOMETER OBSERVATIONS

VELOCITY FROM SMELL TEST *ft. per min.*		TEMPERATURE °*F.*	H/θ	AIR VELOCITY (FT. PER MIN.) ACCORDING TO EQUATION					PERCENTAGE VARIATION FROM SMELL TEST OF VELOCITY OBTAINED FROM EQUATION				
				1 and 2	1 and 2 with Vernon's Corrections	5	3	4	1 and 2	1 and 2 with Vernon's Corrections	5	3	4
Colliery A													
27		77.3	0.302	13		21	.....	.....	31		52		22		...	....		15	
35		77.6	0.381	41		53	.....	48	64		17		51		...	37		83	
40		77.0	0.361	32		43	.....	40	54		20		8		...	0		35	
42	39	78.7	0.377	39	31	52	43	46	43	63	54	7	25	24	19	...	10	13	50	39
43		79.3	0.363	33		46	.....	41	56		23		7		...	5		30	
44		79.8	0.355	30		43	.....	39	53		32		2		...	11		20	
120		78.0	0.455	81		96		93	81		105		32		20		22	32		12	
125		75.2	0.550	151		164		151	138		168		21		31		21	10		34	
169	159	78.8	0.602	199	164	208	176	188	161	175	148	216	184	18	18	23	18	11	14	4	13	28	19
185		80.2	0.569	168		185		164		151		191		9		0		11		18		3	
198		74.6	0.628	221		226		208		195		234		12		14		5		2		18	
200		79.8	0.633	226		233		212		199		248		13		17		6		1		24	
225		74.8	0.624	218		222		205		192		230		3		1		9		15		2	
231		80.0	0.633	226		233		212		199		247		2		1		8		14		7	
240	230	74.2	0.657	248	230	252	234	232	215	219	202	260	244	3	5	5	5	3	8	9	12	8	8
240		73.9	0.623	217		220		204		191		228		10		8		15		20		5	
245		73.5	0.651	242		246		227		214		253		1		0		7		13		3	
Mean variation.....														16		14		11		13		22	
Colliery B																							
25		52.3	0.353	29		27	.....	37	44		16		8		...	48		76	
29		52.8	0.343	26		23	.....	34	41		10		21		...	17		41	
29	29	52.3	0.366	34	29	31	26	42	37	49	44	17	16	7	15	...	45	30	69	54
32		52.2	0.346	26		24	.....	35		42		19		25		...	9		31	
42		52.4	0.399	49		47		66	55		63		17		12		57	31		50	
43		50.2	0.410	54		50		71	60		68		26		16		65	40		58	
43	47	52.5	0.395	47	54	44	51	64	71	53	60	62	68	9	17	2	9	49	52	23	28	44	47
59		50.4	0.432	67		62		81		70		79		14		5		37		19		34	
92		53.2	0.475	93		90		104		92		103		1		2		13		0		12	
97	109	47.7	0.471	91	113	84	107	102	120	90	108	99	118	6	7	13	8	5	10	7	3	2	9
137		47.4	0.555	155		148		154		141		153		13		8		12		3		12	
266		51.7	0.675	265		255		247		235		251		0		4		7		12		6	
Mean variation.....														12		10		31		21		36	

was only 10 per cent. This measure of agreement was closely approached by the values from the same equations without temperature corrections, their percentage divergence being 12 per cent. The poorest correspondence with the smell test values was found in the velocities computed from equation 5, and this lack of agreement occurred at the lower limit of velocities covered by the equation. At velocities of about 100 feet per minute or more the formula gave reasonably good results.

Taking account of both sets of data, the results of the smell test observations appear to agree best with the velocities calculated from equations 1 and 2, using Vernon's temperature corrections. This is due, largely, to the greater accuracy of equation 2 at very low velocities. At the higher velocities there seems, on the whole, to be but little choice between the various formulas.

Smoke Tests

At Colliery A, in addition to the ammonia smell test, we endeavored to measure velocities by the use of a smoke test. As naked lights were not permissible, we were unable to use smoke of combustion; instead, we used fumes of ammonium chloride. Two small trays were used, one containing strong hydrochloric acid, and the other ammonia. When the trays were brought together, the vapors from the acid and the ammonia combined to form whitish fumes of ammonium chloride. These fumes were not easily traced by the light of the safety lamp, and our timings were much less sure than with the smell test. Because of this we abandoned the test after a few attempts. The results of the observations that we made are given below, and it will be seen that they agree reasonably well with the smell test values:

	Velocity ft. per min.				
Fume test...	39	40	40	171	174
Smell test...	35	43	44	185	200

The fume test values were, in four out of the five cases, rather less than those obtained from the smell test. We attribute this to our difficulty in seeing the fumes.

At the naked light colliery we ignited small quantities of a mixture of gunpowder and ammonium chloride. By this means we obtained dense white smoke which could easily be traced. Table 2 shows the results of these tests compared with those of the ammonia smell test, and with the velocities calculated from kata readings.

A comparison of this table with the lower part of Table 1 shows that on the whole, the velocities given by the various kata equations agree with the smoke values to just about the same extent as they do with the results of the smell test. Equations 1 and 2 appear to give the best results.

The values obtained with the smoke and smell tests were not absolutely the same; there was an average difference of 7 per cent. This we ascribe partly to errors of observation, and partly to slight variations in the actual velocity of the air currents.

Summary

Observations made in coal mines are reported in which smell and smoke

TABLE 2.—COMPARISON OF AIR VELOCITIES DETERMINED BY GUNPOWDER SMOKE TEST WITH THOSE OBTAINED BY KATA-THERMOMETER OBSERVATIONS AND SMELL TEST

VELOCITY FROM POWDER SMOKE TEST	SMELL TEST		TEMPERATURE	H/θ	AIR VELOCITY (FT. PER MIN.) ACCORDING TO EQUATION					PERCENTAGE VARIATION FROM POWDER SMOKE TEST OF VELOCITY FROM EQUATION				
ft. per min.	Velocity *ft. per min.*	Percentage Variation from Smoke Test Value	*°F.*		1 and 2	1 and 2 with Vernon's Corrections	5	3	4	1 and 2	1 and 2 with Vernon's Corrections	5	3	4
27	.....	.....	52.2	0.351	28	26	.....	37	43	4	4	.....	37	59
29 } 30	29	0	52.8	0.343	26 } 27	23 } 25	.....	34 } 36	41 } 43	10 } 9	21 } 15	.....	17 } 22	41 } 45
30	25 } 29	17 } 6	52.3	0.353	29	27	.....	37	44	3	10	.....	23	47
32	32	0	52.2	0.346	26	24	.....	35	42	19	25	.....	9	31
40	42	5	52.4	0.399	49	47	66	55	63	23	18	65	38	58
46 } 48	43 } 48	7 } 4	52.5	0.395	47 } 54	44 } 51	64 } 70	53 } 59	62 } 68	2 } 13	4 } 9	39 } 47	15 } 24	35 } 42
59	59	0	50.4	0.432	67	62	81	70	79	14	5	37	19	34
83	97	17	47.7	0.471	91	84	102	90	99	10	1	23	8	19
84 } 147	92 } 148	10 } 9	53.2	0.475	93 } 151	90 } 144	104 } 152	92 } 140	103 } 152	11 } 8	7 } 5	24 } 16	10 } 9	23 } 14
144	137	5	47.4	0.555	155	148	154	141	153	8	3	7	2	6
277	266	4	51.7	0.675	265	255	247	235	251	4	8	11	15	9
Mean variation ...		7	.....	.....	.....	.....	.....	.....	.....	10	10	29	18	33

were used to test air velocities, otherwise measured by the dry kata-thermometer.

Although the new observations which we have adduced are not numerous, they serve as a practical demonstration that the dry kata-thermometer is really a reliable instrument for use as an anemometer, even at very low velocities.

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RATIONAL METHOD FOR CALCULATING RECORDS OBTAINED BY MEANS OF OWENS' JET DUST COUNTING APPARATUS*

DR. M. KAGAN AND DR. W. BROUMSTEIN

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OWENS' counter is a very well known and much used portable apparatus for taking records and making microscopic slides in any dusty workplace. The actual methods of direct dust counting, however, are so minute and require so much time that the convenience of the apparatus is considerably diminished; moreover, the lack of uniformity in counting technic renders difficult a comparison of the counts reported by different authors working with this instrument.

Records obtained with Owens' counter consist of a linear deposit of dust, often markedly condensed into patches at one end or both ends

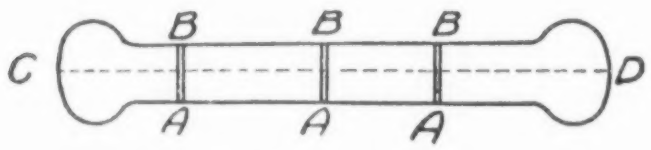

FIG. 1.—Diagram of dust record.

(Fig. 1). The length of the dust record depends theoretically on the length of the narrow orifice through which the air is drawn into the apparatus—that is, 1 cm.; when measured with the ruler on the stage of the microscope, it varies, according to our data, from 9.2 to 9.8 mm., averaging 9.5 mm. The width of the dust ribbon, measured in squares of the eyepiece micrometer (usually employed when counting records) has been ascertained, in our experiments, to be from eighteen to forty squares—that is, from 0.3 to 0.6 mm. For counting, a Zeiss 4 eyepiece and a $\frac{1}{12}$-inch oil immersion Zeiss objective are used.

The methods usually employed for counting dust records differ in respect to: (1) the number of cross sections used for calculations—for instance, the Kharkoff Institute of Hygiene and Pathology of Labor takes into account from twenty-five to fifty, Teleky and our Institute use ten, and Middleton does not go beyond five, sometimes using three, two, and even one; (2) the manner in which the coefficient is computed; and (3) the way in which the dense areas are evaluated.

The aim of the present work, which constituted part of the researches conducted in our Institute with Owens' apparatus, was to find a simplified and uniform method for calculating records. Therefore the first step was a thorough study of the laws governing the distribution of the dust particles across and along the record.

DISTRIBUTION OF PARTICLES ON CROSS SECTION OF RECORD

In records differing in respect to the nature of the dust and the quantity of air drawn into the apparatus, counts of the dust particles in each square of the micrometer eyepiece along the

* Received for publication April 17, 1930.

entire cross section of the dust ribbon (direction AB in Fig. 1) disclosed a definite order in the distribution of the particles. At the edges of the ribbon the particles are sparse, but their number increases toward the center,

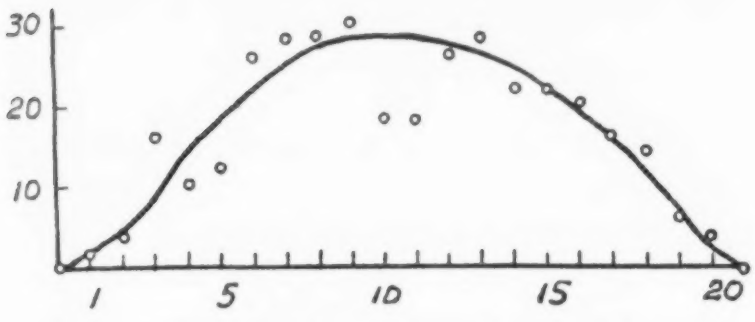

FIG. 2.—Distribution of particles on cross section of dust record.

Abscissas = millimeter squares of micrometer placed against record; ordinates = number of particles in each square.

where it reaches a maximum. This distribution of the particles does not depend either on the kind of dust or on the quantity of air drawn into the apparatus. Samples with metallic dust, silica, and tobacco (the volume of air drawn in the different records varied from 50 to 500 c.c.) showed identical distribution of particles.

The order[1] of distribution is clearly illustrated by typical curves in Figures 2 and 3, in which the axis of abscissas gives the position of the millimeter squares of the micrometer against the cross strip of the record, and the axis of ordinates shows the number of dust particles in each square. Thus the area limited by the distribution curve represents the sum of all the particles present in the section chosen. The shape of this curve approaches closely that of a triangle, and therefore the area of a triangle may be substituted with great accuracy in place of a calculation of the area bounded by the curve.

For practical purposes the distribution curve need not be given in such detail as is represented in Figures 2 and 3; that is, it is not necessary to count the particles in all the squares of the entire cross section. The area bounded by the distribution curve may be easily calculated by constructing an equivalent triangle by means of several definite points. Our experience shows that for plotting such a triangle it is sufficient to count the particles at four representative points (squares of the micrometer)—namely, two from the denser part (center) and two from the thinner parts (nearer the edges). In accordance with the data

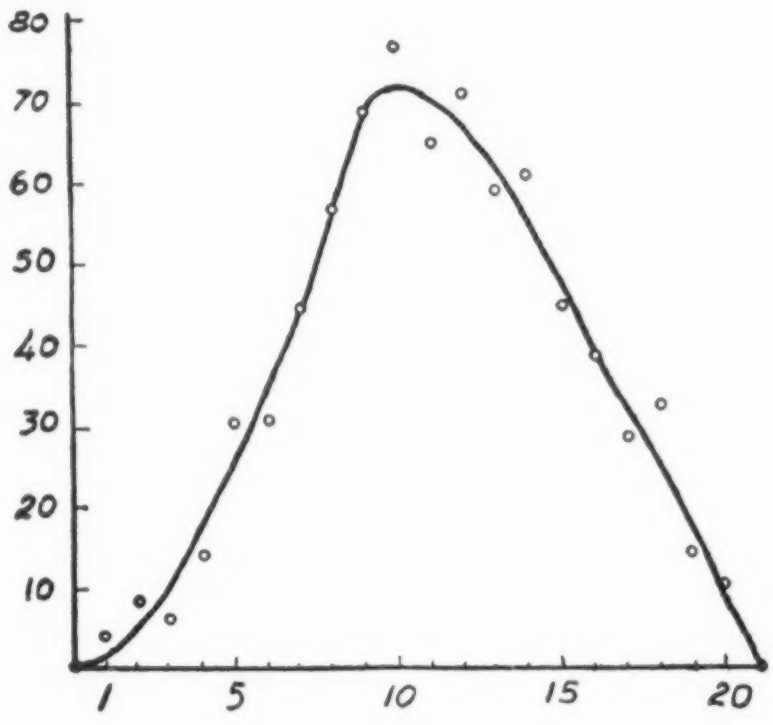

FIG. 3.—Distribution of particles on cross section of dust record.

Abscissas and ordinates are the same as in Figure 2.

thus obtained, the triangle is constructed as follows: Mark the position of the zero points (at the beginning and end of the cross section) and of the calculated points; then draw the two sides of the triangle so that each is

[1] An analogous order of distribution of the dust particles was established by Blinow (1) in the Physical Laboratory of our Institute in the course of counting records obtained with an electric filter.

within equal distance of the three points determining it (one zero point and two calculated points). Figure 4 shows such a triangle; the double circles indicate the position of the zero and calculated points defining the straight lines AB and CD which form the sides of the triangle. Point K, lying at the intersection of these two straight lines, is the apex of the triangle. The distance between the zero points represents the cross section

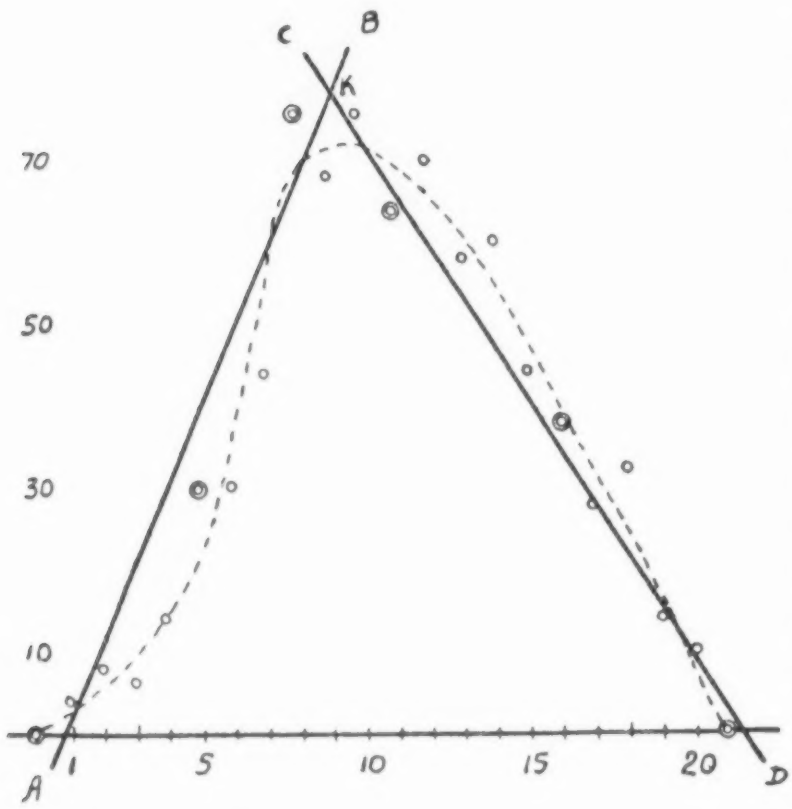

FIG. 4.—Triangle constructed according to distribution curve.

of the record divided into squares by the lines in the micrometer. The segment formed by the intersection of lines AB and CD with the line connecting the zero points constitutes the base of the triangle. The dotted line represents the distribution curve of the particles. The area of this triangle is almost equal to that bounded by the distribution curve and will give the sum of the dust particles contained in the cross section of the dust record.

Example in Calculating a Triangle

The distance between the zero points (length of the cross strip) = 21 squares; the number of dust particles in square 5 = 30, in square 8 = 76, in square 11 = 64, and in square 16 = 38.

The height of the triangle plotted according to these data = 79, the base = 20.5, and the area = $\frac{79 \times 20.5}{2}$.

Hence the cross fraction contains 810 particles.

The question naturally arises: Does this number agree with the number obtained by direct count under the microscope? Our numerous observations (seventy-eight) show that, for cross strips, the deviation of the values calculated graphically from the values obtained by direct count varies from 0 to ± 20 per cent. Notwithstanding the marked degree that this percentage may reach, a reasonably close agreement will be secured in the final calculation if averages are established for from five to ten triangles (cross strips). The deviations neutralize each other, and the accuracy of the final calculation is thus considerably increased. The percentage deviation between counts obtained from an average triangle and those obtained from an average cross strip does not, according to our observations, exceed 2.1; it remains therefore within the limits of permissible error. For illustration see Tables 1 and 2.

In Table 1 are given the counts for one of our records. In every cross section the number of particles was ascertained by direct count and by graphic interpretation. The figures for individual cross sections showed deviations as great as 3.2 per cent. and

5.1 per cent., but the averages for ten calculated cross sections and ten calculated triangles were almost equal, the deviation being only 0.2 per cent.

TABLE 1.—COMPARISON OF RESULTS OF DIRECT COUNT AND OF GRAPHIC INTERPRETATION OF PARTICLES IN TEN CROSS SECTIONS OF A SINGLE RECORD

CROSS STRIP NO.	COUNT OF CROSS STRIP	PLANE OF TRIANGLE	PERCENTAGE DEVIATION
1	1,099	1,064	−3.2
2	306	306	0.0
3	317	313	−1.3
4	507	505	−0.4
5	326	324	−0.6
6	246	250	+1.6
7	300	315	+5.0
8	612	643	+5.1
9	446	442	−0.9
10	1,537	1,522	−1.0
Average.	569	568	−0.2

TABLE 2.—COMPARISON OF RESULTS OF DIRECT COUNT AND OF GRAPHIC INTERPRETATION OF PARTICLES IN A SERIES OF RECORDS

RECORD NO.	NO. OF CROSS STRIPS COUNTED	PERCENTAGE DEVIATION OF SEPARATE TRIANGLES FROM COUNTS		AVERAGE COUNT	AVERAGE TRIANGLE	AVERAGE PERCENTAGE DEVIATION
		Maximum	Minimum			
1	10	9.6	1.0	135	137	+1.5
2	6	18.0	2.5	167	166	−0.6
3	10	5.0	0.0	569	568	−0.2
4	9	17.0	0.0	243	248	+2.1
5	8	20.0	2.0	401	409	+2.0
6	5	4.5	2.4	502	502	0.0
7	5	8.9	0.9	517	506	−2.1
8	5	10.4	1.9	391	386	−1.3
9	11	7.0	0.1	535	528	−1.3

In Table 2 we have comparative counts obtained by the direct and by the graphic method for a series of records. In spite of the marked degree of the maximum deviation in individual cases (20, 18, 17 per cent.), the final calculation lowers the percentage of error to 2.1 per cent.

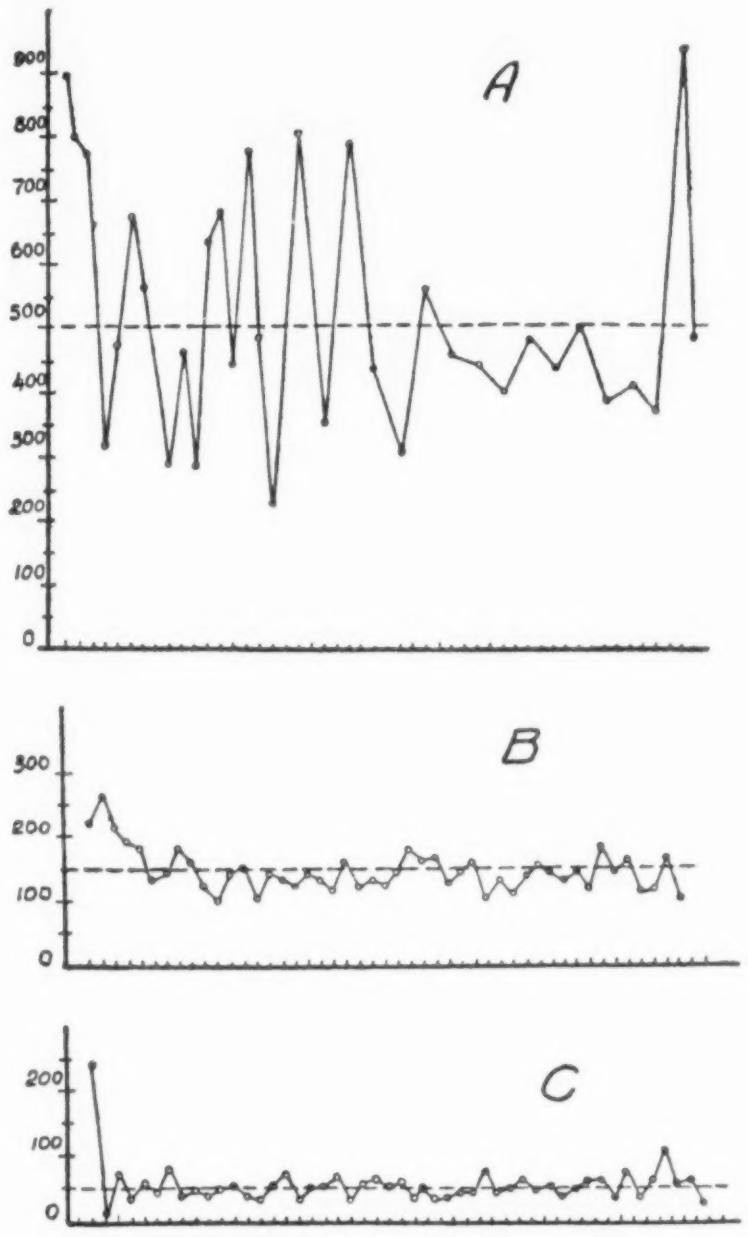

FIG. 5.—Distribution of particles lengthwise of dust record.

Abscissas = distances of calculated cross sections from beginning of dust record; ordinates = number of particles in each cross section. The average number of dust particles in one cross section is designated by the dotted line.

DISTRIBUTION OF PARTICLES LENGTHWISE OF RECORD

In the distribution of the particles lengthwise of the dust ribbon (Fig. 1, along the line *CD*), we have detected

no definite order. Figure 5 shows that the number of dust particles in separate strips fluctuates within certain average values, with deviations to either side amounting sometimes to 80 per cent.

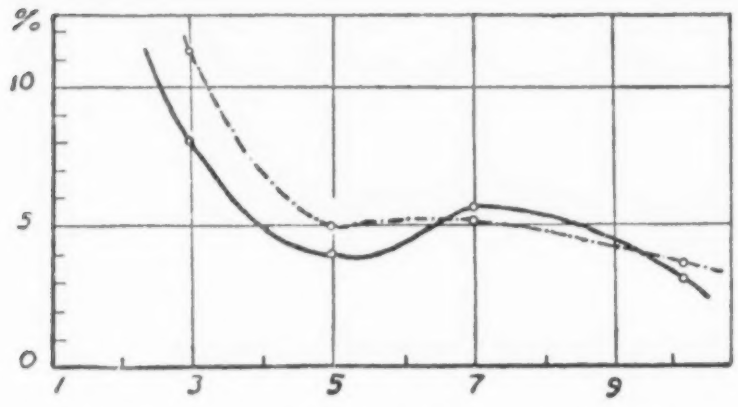

FIG. 6.—Sample of tobacco dust; 50 c.c. of air drawn.

Abscissas = number of calculated cross sections from which average values were plotted; ordinates = percentage deviation of calculated average from average of detailed counts.

The dotted line = deviations from random counts; the continuous line = deviations from equidistant counts.

Absence of any noticeable law in the distribution of particles along the record made it necessary to calculate the loci for the counts and to fix their

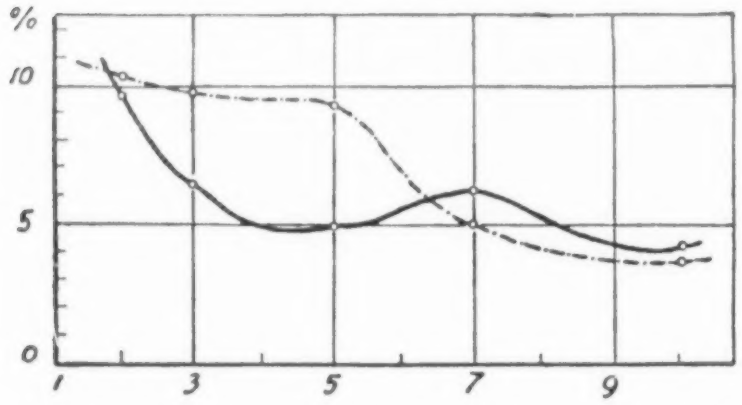

FIG. 7.—Sample of magnesite dust; 50 c.c. of air drawn.

In this and following figures, abscissas, etc., are the same as in Figure 6.

number. This could be done only by comparing results obtained by direct count of the particles along the whole record with those yielded by some simplified estimation. The method adopted in our researches was, in the main, as follows: On six records of different kinds of dust (tobacco, magnesite, and dust from polishing and grinding machines) with different volumes of air drawn (from 50 to 400 c.c.)

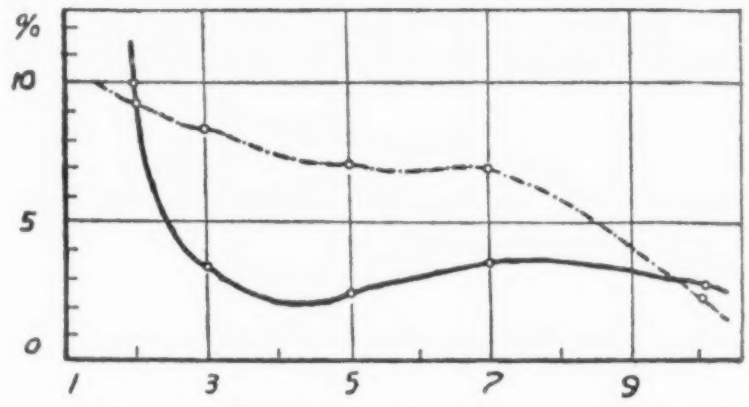

FIG. 8.—Sample of dust produced by grinding machines; 100 c.c. of air drawn.

particles were counted in from forty to fifty cross strips at intervals of 0.2 mm.; the average number of particles falling in one cross section was then determined. As this average value is computed from a considerable number of observations, it is safe to conclude that it is characteristic for the whole dust ribbon—that is, that the result obtained by multiplying this number by the number of cross sections along the record gives the nearest approach to the actual number of dust particles in the entire dust ribbon.

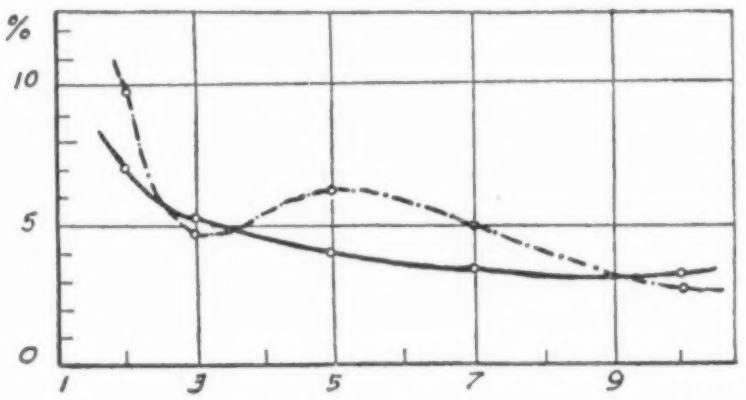

FIG. 9.—Sample of dust produced by grinding machines; 100 c.c. of air drawn.

After these detailed counts had been made, each of the records was sub-

jected to a series of combined counts of 10, 7, 5, 3, and 2 cross strips chosen at equal distances from each other (every 1.5, 1, 0.8 mm., etc.). The average numbers of particles in a cross strip obtained by these simplified

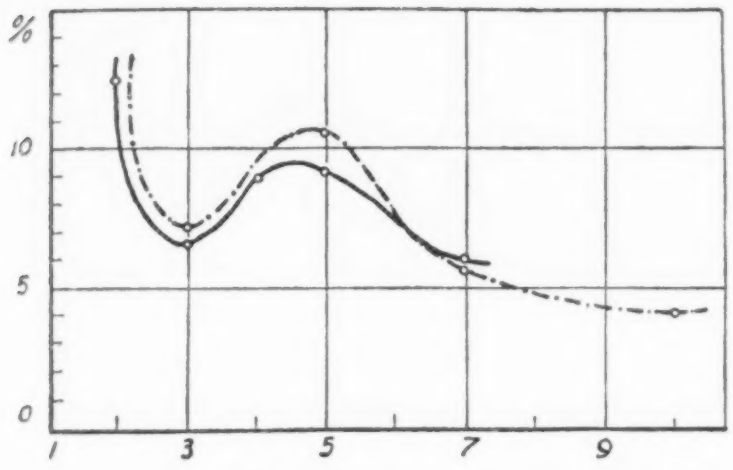

FIG. 10.—Sample of dust produced by grinding machines; 200 c.c. of air drawn.

counts were compared with the average obtained in the detailed enumeration. Besides comparing results of counts made at equal distances (equidistant counts), we also compared random counts. Data yielded by analysis of the dustiness of the record are illustrated in Figures 6 to 11.

We see from the curves that the error decreases abruptly with the increase in the number of cross sections

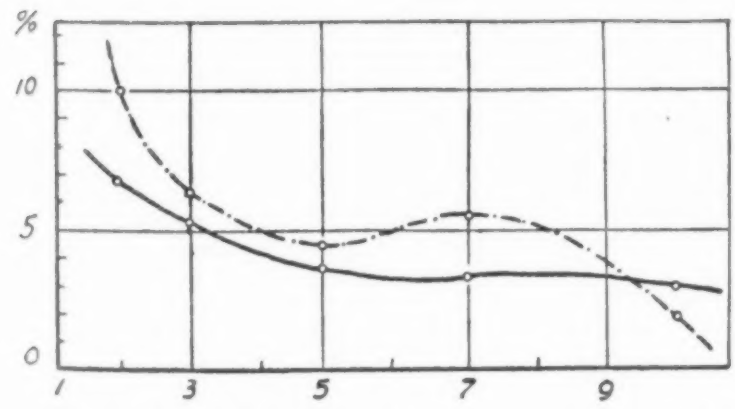

FIG. 11.—Sample of dust produced by grinding machines; 400 c.c. of air drawn.

counted; it remains almost constant at a certain interval—between the fourth and the eighth strips—for both equidistant and random counts. In equidistant counts the deviation at this interval, according to our observations, varies between 3 and 6 per cent., except in one instance where it reached 9.5 per cent.; in random counts it remains within the limits of 4.5 and 10.5 per cent. When ten cross strips are counted, regardless of the method applied, the error does not exceed 4 per cent. Our observations show that the error curve is somewhat more regular and uniform with the equidistant counts.

We may conclude from the foregoing that on records with an even layer of dust (see for example Fig. 5, B and C), it is necessary to count only a few cross strips (triangles)—say, five—to avoid falling into serious error. On slides with an uneven layer of dust (Figs. 5A and 10), a greater number of calculated triangles—nine or ten—should be counted for the sake of accuracy. With regard to the selection of loci for the counts, we believe that it answers the purpose better to calculate triangles at equal intervals, in spite of the fact that this method has only very slight advantages; in this way a series of errors, such as is possible in the arbitrary choice of loci, is avoided.

COUNTING PARTICLES IN DENSE PATCHES AT ENDS OF RECORD

As was mentioned above, the dust record very often presents at the ends dense patches which occupy from five to ten squares on the micrometer—that is, from 1 to 15 per cent. of the complete length of the record. The question naturally arises whether these dense areas must be evaluated; and if so, by what means? In the literature this question has been touched upon

only by Rosenthal-Deussen and Teleky, who consider these patches as a constant phenomenon and consequently requiring quantitative determination. Their method was to count the particles in ten strips on a record, including several from the dense areas at the ends of the dust ribbon, and then to determine the average of these ten counts. Since the number of particles in a strip of the thick layer, according to Rosenthal-Deussen and Teleky, is more than twice that in a cross strip in the middle of the record (we have observed values three and four times higher), the average will naturally be much increased. When we tried this method and calculated the average for ten cross strips, we obtained a value of 72 when the dense areas were included, and a value of 52 when they were omitted; in another such experiment the values were, respectively, 570 and 306.

TABLE 3.—COMPARISON OF COUNTS WHEN DENSE AREAS ARE INCLUDED AND WHEN DENSE AREAS ARE OMITTED

RECORD NO.	NO. OF PARTICLES IN 1 C.C. OF AIR		PERCENTAGE DEVIATION	LENGTH OF RECORD	NO. OF DENSE AREAS
	Dense Areas Included	Dense Areas Omitted			
				mm.	
1	2,069	2,100	+1.5	9.5	1
2	1,561	1,668	+6.8	9.3	1
3	2,202	2,256	+2.5	9.5	1
4	1,421	1,478	+4.0	9.6	1
5	1,441	1,455	+1.0	9.2	2
6	1,750	1,766	+0.9	9.4	2
7	1,454	1,452	−0.1	9.6	1
8	1,449	1,464	+1.0	9.6	2
9	947	964	+1.8	9.5	2
10	3,393	3,376	−0.5	9.8	2
11	1,327	1,368	+3.1	9.6	1
12	1,179	1,200	+1.8	9.7	2
13	2,407	2,514	+4.4	9.7	1
14	1,440	1,427	−0.9	9.8	1
15	984	971	−1.3	9.7	2
16	1,965	1,924	−2.1	9.8	2
17	2,585	2,580	−0.2	9.5	1
18	1,359	1,344	−1.1	9.5	2
19	2,825	2,745	−2.8	9.5	1
20	1,565	1,552	−0.8	9.8	1

It is quite evident that such a method of estimating the dense patches must be given up. We have therefore tried to approach the problem in another way, by treating the thick deposits at the ends of the record as independent samples. We determined the total number of particles in one cross strip of these areas and multiplied it by the number of cross sections in the areas (from five to ten, in our experiments). The value thus obtained was added to that found for the total record, dense patches excepted. For greater accuracy the length of the dust record was measured each time with the ruler on the microscope stage, and the coefficient was computed from the figure obtained.[2]

[2] The value of the record is calculated by means of the following formula: $X = \frac{N^S}{C} = N\frac{S}{C}$; where X is the number of particles in 1 c.c. of air, N the average number of particles in a cross strip, S the number of cross strips in the whole record (within the given optical conditions), C the volume (cubic centimeters) of air drawn. Given a constant length for the dust ribbon, equal optical conditions, and a constant volume of air, the coefficient is a constant value. S is the function of the record, but as its actual length varies only very slightly (from 9.2 to 9.8 mm., averaging 9.5 mm., in our experiments) and as these variations affect the value S but little, in order to simplify the calculations our Institute accepts the length as 1 cm., as do Owens and Middleton; this corresponds to the length of the orifice of the apparatus. Rosenthal-Deussen and Teleky make their calculations from the actual length of the record—9.2 mm., according to their data.

From the foregoing we see that the estimation of records including counts from the dense patches and evaluation of the actual length of the sample is tedious and minute work. We cannot help wondering whether the time and the work it requires are entirely justified. Data presented in Table 3 supply an answer to this question. They represent the results of counts obtained with the same records: (*a*) with estimation of the dense areas and the actual length of the sample, and (*b*) without estimation of these areas and with the usual coefficient. In the fourth column is given the percentage of error for the second method of counting. It is obvious from this table that for the general characteristics of the dust record, evaluation of the dense areas at the ends of the sample is unimportant and may be omitted; counts without these areas and with a coefficient calculated from the length of the record taken as 1 cm. are entirely adequate.

Advantages of Proposed Method

Experimental findings show that counting records of medium density by the old method requires from 50 to 60 per cent. more time than estimating them by the graphic method (triangles). The economy in time is particularly great when one is dealing with dense records where particles are counted by the thousand. Moreover, counting the particles in the whole cross section produces fatigue of the eyes which impairs the accuracy of the enumeration. Graphic interpretation does not produce this fatigue, because it reduces the number of micrometer squares counted in every cross strip from between eighteen and forty to four (and from between 180 and 400 to forty, when ten cross strips are counted); it therefore contributes to greater accuracy in the counts. Moreover, counting the particles alternates with plotting the triangles and calculating them; this gives the worker an opportunity to rest his eyes, and thus lessens eyestrain. Lastly, the possibility of counting a small number of triangles and not being obliged to estimate the dense areas at the ends of the record saves still more time and enables the worker to experiment on a larger number of records.

Summary

Observations on the order of distribution of the dust particles in the record obtained by Owens' dust counter allow the following conclusions:

1. The direct counting of dust particles in a cross strip may be replaced by the calculation of the area of a triangle constructed with the help of six guiding points (two zero and four calculated points).

2. On records with an even layer of dust it is sufficient to calculate a small number of triangles—say, five; on records with an uneven layer a greater number should be calculated—ten, for example. To avoid subjective choice, cross strips should be chosen at equal distances.

3. It is not necessary to establish a new coefficient in each case by measuring the actual length of the record, since counts derived from a length assumed as 1 cm. give but very slight deviations.

4. Counting the dense areas has no significant effect upon the results of evaluation of the record and, what is more, it complicates the work con-

siderably; consequently it may be omitted.

5. The method here described may be considered adequate, since it not only contributes to greater accuracy in the counts, but also saves time and lessens the fatigue of microscopic work.

We wish to express our thanks to Professor A.-S. Predvoditeleff, Director of the Physical Laboratory, for his ever-ready counsel and many valuable suggestions.

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COAL MINERS' LUNG: A RADIOGRAPHIC STUDY OF CERTAIN GROUPS OF INDUSTRIALLY HEALTHY SOUTH WALES COAL MINERS*

THE KING EDWARD VII WELSH NATIONAL MEMORIAL ASSOCIATION

INTRODUCTION

THIS preliminary study was undertaken by three selected Teams of the Medical Staff of the Welsh National Memorial Association, each of which was so placed as to be able to study miners employed in getting a different type of coal. It was a preliminary inquiry confined to the examination of men in working health, and was intended to furnish a basis from which to proceed in any subsequent investigation into the radiographic appearances in the chest diseases of coal miners.

With a view to obtaining a comparison between the chest radiographs of healthy coal miners and those of persons not exposed to coal dust, Dr. H. E. Watson, Medical Superintendent of the South Wales Sanatorium, Talgarth, Brecon, kindly provided a series of twelve X-ray photographs of healthy agricultural workers of ages comparable with those of the colliers examined. Four of these are here reproduced for comparison with the four radiographs which accompany each of the Team reports.

The members of the three Teams, whose reports are now introduced, frequently met to discuss progress and to compare and discuss their methods of investigation. In these meetings, Dr. D. A. Powell, Principal Medical Officer of the Welsh National Memorial Association, Professor S. Lyle Cummins, Professor E. L. Collis, and Dr. H. E. Watson took part. Thus close touch between the workers was assured.

The general program of work, as arrived at during these meetings, was as follows:

1. To discover, by the examination of coal miners (preferably over 40 years of age) who have been working as hewers for a period of fifteen years or over, but excluding men who have worked in hard headings, whether they show abnormal X-ray appearances, these appearances, nevertheless, being consistent with ability to work.

2. To ascertain whether, in the case of coal miners of the foregoing groups, abnormal X-ray appearances are found to be associated with alterations in chest expansion and general physique; or with alterations in vital capacity where facilities for recording the latter are available.

Groups of healthy coal hewers from anthracite collieries, steam coal collieries, and semibituminous collieries to be studied in relation to the following points:

Details of Employment.—(*a*) Duration of employment as worker in coal. (*b*) Capacities in which employed, with length of time: dusting, hewer, etc. (*c*) Kind of coal worked, *e.g.*, semibituminous, steam, anthracite.

Physical Records.—(*a*) Standing height without boots. (*b*) Chest measurement at nipple line in full expiration and full in-

*Received for publication June 30, 1930.

spiration. (*c*) Weight in shirt and trousers. (*d*) Spirometer records where obtainable.

Standardized X-Ray Technic.—(*a*) Position of patient: standing with tube to back, arms drawn forward and rotated inward to remove shadows of scapulae. (*b*) Phase of respiration: partial inspiration. (*c*) Position of tube: focus of tube centered at level of third chondrosternal joint. (*d*) Film target distance: 30 inches, approximately (duplicate at 36 inches in certain type cases). (*e*) Spark gap: 4 inches, approximately. (*f*) Current: 20 milliamperes. (*g*) Exposure: will vary with thickness of patient. (*h*) Screen: double intensifying to be used. (*i*) Films: kodak-contrast. (*j*) Developer: kodak. (*k*) Fixing: kodak. (*l*) Time and temperature of developer: approximately six minutes at 65°F.

Although the members of all three Teams kept in close touch throughout the investigation, it was agreed that each Team should work on its own lines in regard to the assessment of radiographs. The Team engaged in studying miners in steam coal from the Rhondda Valley worked out its own method of classification; the Team investigating miners from the bituminous and semibituminous coal seams of the Nine Mile Point and Llanbradach Collieries used the classification recently introduced by Dr. Irvine of the Miners' Phthisis Bureau, Johannesburg; while Dr. Jordan and Dr. Clark, examining anthracite coal miners, employed a system of assessment suggested by Professor Cummins, which is described in their report.

It is significant that although each Team used a different system, all were led to the conclusion that mottling, usually fine but in some cases coarse, was a conspicuous feature in the films examined; and that this evidence of lung fibrosis became more marked with increasing years of exposure to mine dust. While it was realized that much was to be gained by allowing to each Team full latitude in selecting its own method of reading and evaluating its films, it was felt, also, that a comparison of the films from each type of coal miner ought to be made on standard lines.

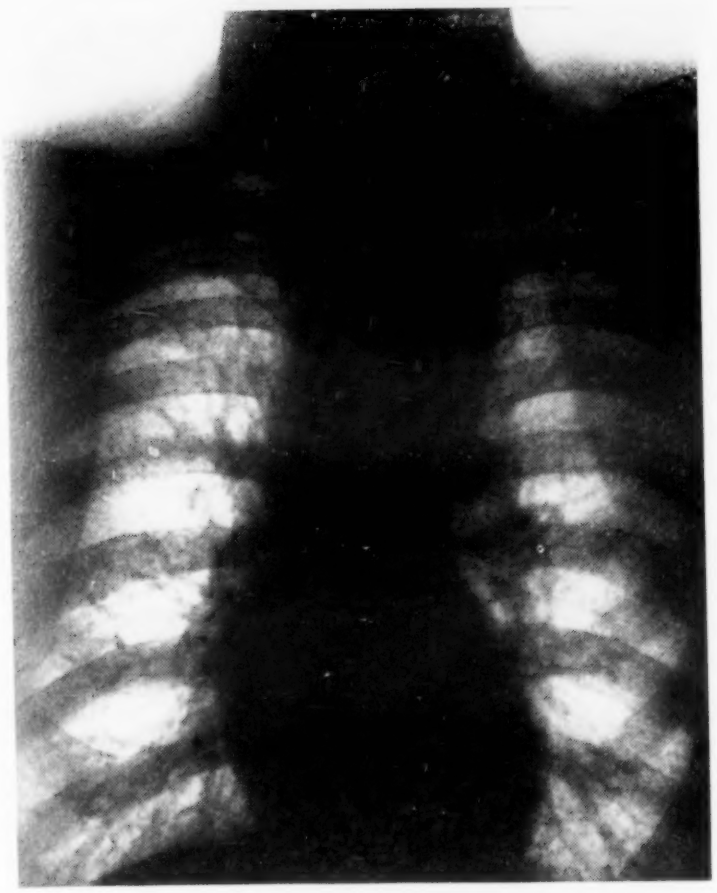
For this purpose all the Teams submitted their films to Dr. Jordan and Dr. Clark in order that readings should be made according to the method suggested by Professor Cummins, which is briefly as follows:

> Marks up to a maximum of 10 to be allotted to each film under each of the three headings, mottling, arborization, and diffuse shadows. The total marks allotted under each heading for the whole group to be added together and the result expressed as a percentage of the possible marks.

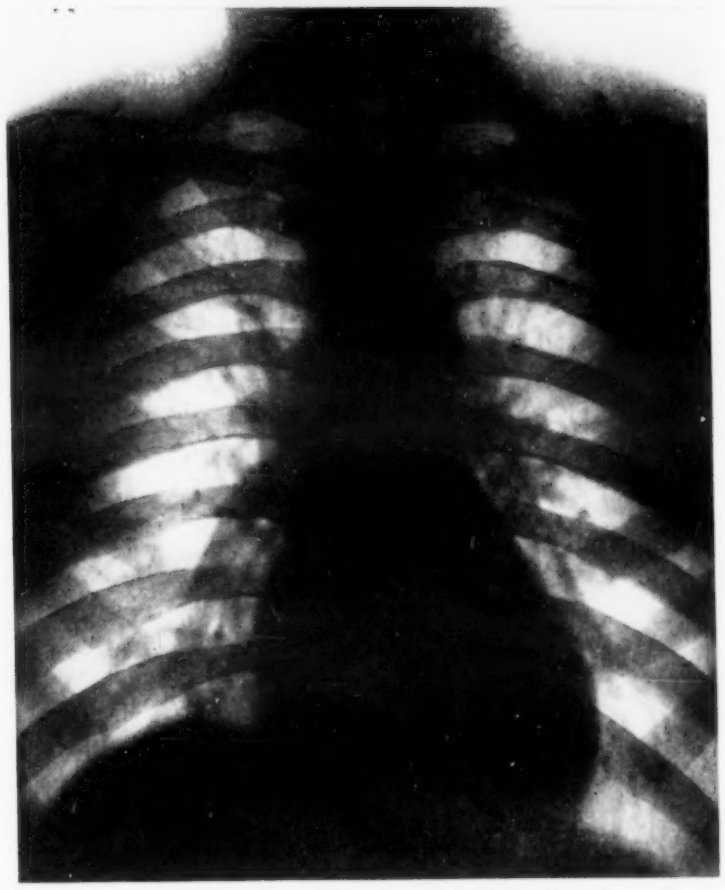
TABLE 1.—COMPARISON OF CRAIG-Y-NOS WITH OTHER GROUPS

AREA	NO. OF FILMS	AVERAGE AGE	PERIOD UNDER-GROUND	MOTTLING
		yrs.	*yrs.*	%
Craig-y-nos (anthracite).....	42	48.0	32	72.4
Glan Ely (steam coal).....	48	50.0	34	34.0
Cefn Mably (semibituminous).....	40	42.5	28	48.0

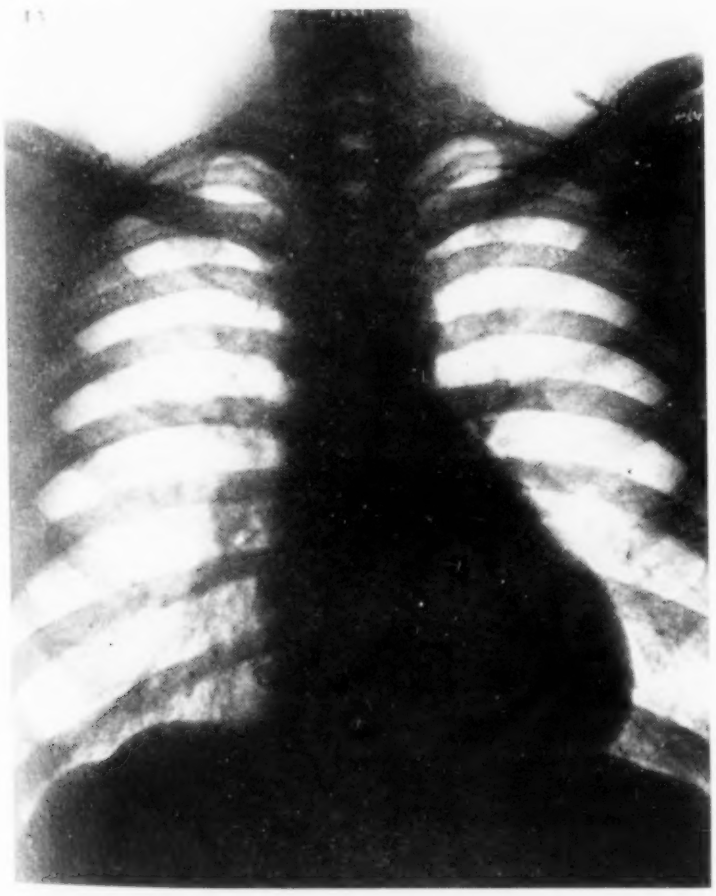
A comparison between the films taken at Craig-y-nos, Glan Ely, and Cefn Mably is of considerable interest; Table 1 shows that the films are com-



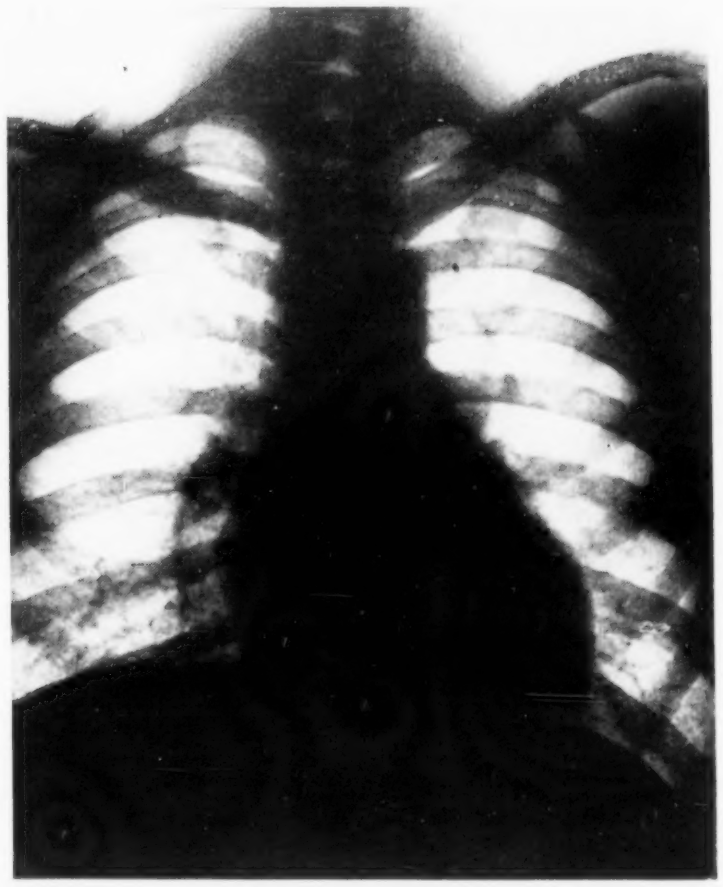
J. M., gardener, aged 46. No illness except colds.
Marked arborization; no mottling.



A. W. F., farm laborer, aged 36. No previous illness.
Slight arborization.



O. P., farmer, aged 30. Had had pneumonia some time before.
Slight arborization.



D. P., agricultural worker, aged 29. No previous illness.
Trace of arborization at or near bases.

Radiographs of workers in agriculture, for comparison with coal miners.

parable with regard to age and length of work.

The results for the four groups of X-ray films, including those from the agricultural workers, are given in Table 2.

TABLE 2.—COMPARATIVE FIGURES FOR FOUR GROUPS OF FILMS

AREA	NO. OF FILMS	MOTTLING	ARBORIZATION	DIFFUSE SHADOWS
		%	%	%
Talgarth (healthy men)	12	6.0	38	3.0
Craig-y-nos	42	72.4	29	8.9
Glan Ely	48	34.0	15	6.0
Cefn Mably	40	48.0	26	0.0

The mottling present in the anthracite workers is over twice that in the workers in steam coal, and it seems probable that further research will be necessary to elucidate the cause or causes of such a marked difference.

From these investigations and comparisons it seems certain that within the span of a miner's working life and while he still retains what may be called working health, exposure to the dust of the coal mines, and, perhaps, especially to the dust of the anthracite coal mines, leads to marked alterations in the lungs, visible in X-ray films and comparable, in many respects, to the alterations regarded as characteristic of silicosis. That such appearances are consistent with working health is a fact which has a very important bearing upon the interpretation of radiographs in cases of pneumonokoniosis.

With prolonged exposure to the inhalation of coal dust and the dusts associated with it in the mines, and with the development of lung fibrosis as seen in X-ray films, there goes a tendency to a gradual deterioration which, though insufficient to lead at once to industrial disability, becomes apparent in diminished chest expansion, lowered vital capacity, and some loss of weight. The relation of this gradual change to actual pulmonary disease requires a moment's consideration before bringing these introductory paragraphs to a close.

The blackening of the lungs of city dwellers, a condition recognized as common in past centuries, was shown by Pearson (1), in 1813, to be due to the accumulation of carbon particles, "coaly matter," to use his own expression, in the pulmonary lymphatic glands and tissues of the lungs. The term anthracosis to describe this deposit of carbon appears to have been first introduced by Stratton in 1838, to distinguish it from the more malignant condition of melanosis.

While mere anthracosis was usually regarded as consistent with health, an association between coal mining and affections of the lung has long been claimed to exist. Early in the last century, Patissier (2) remarked on the prevalence of asthma among coal miners. William Thomson (3), in 1837, wrote an excellent paper on black expectoration and the deposit of black matter in the lungs, particularly as occurring in coal miners, in connection with chest complaints, associating it, however, not only with coal dust but

with working in the hard stone between the coal seams.

Later in the century, Greenhow (4) told of this trouble prevailing among coal miners in South Staffordshire and in South Wales. For a full bibliography of this subject, the reader is referred to an excellent paper by Willis (5), who carried out interesting experiments in the exposure of animals to coal dust in 1921.

This blackening of the lungs, to which coal miners are undoubtedly subject in especial degree, has not, however, been universally accepted as a pathologic condition; in fact, the claim has been made that coal dust may even exert a protective influence against tuberculosis. As against any such protective influence, however, stands the undoubted fact, brought clearly to light by Dr. Norman Tattersall (6), that men exposed to silica dust in coal mines while driving roads through sandstone rocks succumb to silicosis and tuberculosis just as if the dust risk were in no way modified.

Without doubt, in lungs which have become fibrotic as the result of silicosis, coal dust may collect in such amount as to exert an injurious, and possibly a fatal, influence, as shown in a case of which the pathology has been described by Cummins (7).

A recent paper by E. L. Collis and J. C. Gilchrist (8), dealing with the effects of dust exposure on coal trimmers in South Wales indicates that these men tend to succumb in excess from bronchitis and pneumonia, but not from phthisis; while their lungs, on X-ray examination, exhibit signs similar to those widely regarded as characteristic of silicotic fibrosis. These trimmers, working in the holds of ships, are exposed at different times to dust arising from all types of coal—bituminous, steam, and anthracite. The present research suggests that the inhalation of dusts arising from these different types of coal may be followed by different results.

Turning from the variations in the X-ray appearances of the lungs of healthy miners working in different types of coal, it is interesting to pass on to a consideration of their variations in pulmonary disease. The following details have been supplied by Professor E. L. Collis, to whom the Association is greatly indebted for his kind assistance in connection with the present investigation.

Mortality from pulmonary diseases among coal miners in England and Wales has long been known to vary greatly on the different coal fields, as may be seen from the comparative mortality figures for ages 25 to 64, inclusive, which are given in Table 3.

Lancashire stands out above the other fields at both periods for each of the three causes of death; nevertheless, in the case of phthisis, the mortality was well below the standard set for the Kingdom by occupied and retired males; but for pneumonia, and even more so for bronchitis, the mortality was in excess of the standard. The mortalities experienced on the South Wales coal field stood in 1900 to 1902 close up second; in 1910 to 1912 they had undergone definite improvement, but still the mortality from bronchitis stood distinctly high.

The most recent Decennial Supplement (9) dealing with occupations contained more detailed information, since the mining occupations are so subdivided that data relating to hewers

and getters, who comprise 530 out of every 1,000 persons returned as belonging to the coal mining industry, are kept separate from those for other underground workers and for workers above ground. Further, the data for the South Wales coal field are subdivided into three districts which comprise: (*a*) the eastern or Monmouthshire area, wherein most of the coal got is soft bituminous or house coal; (*b*) the mid or Glamorgan area, wherein most of the coal got is steam coal; and (*c*) the western area, wherein a large proportion of the coal is anthracite.

Hewers or coal getters, at least on the South Wales coal field, are mainly exposed to the dust arising from the coal they work; as will be seen in the Team reports, however, they may sometimes perform duties which in-

TABLE 3.—COMPARATIVE MORTALITY FROM PULMONARY DISEASES AMONG COAL MINERS IN ENGLAND AND WALES, AGES 25 TO 64, INCLUSIVE

COAL FIELD	1910–1912			1900–1902		
	Phthisis	Pneumonia	Bronchitis	Phthisis	Pneumonia	Bronchitis
Nottinghamshire	53	40	25	64	52	49
Derbyshire	70	34	39			
Northumberland and Durham	70	54	33	84	54	41
Yorkshire	81	69	45	88	71	67
Monmouthshire and South Wales	70	69	66	93	108	104
Lancashire	107	100	88	96	149	113
All coal fields	76	64	51	89	86	79
All occupied and retired males	142	66	38	187	92	58

TABLE 4.—STANDARDIZED MORTALITY (C. M. F.) OF COAL HEWERS, AGED 20 TO 65 YEARS, FROM CERTAIN PULMONARY DISEASES, 1921 TO 1923

COAD FIELD	RESPIRATORY TUBERCULOSIS	PNEUMONIA	BRONCHITIS
Nottinghamshire	95.3	62.3	53.5
Derbyshire	68.9	60.3	65.0
Northumberland	98.9	73.4	47.6
Durham	85.5	71.7	38.8
Yorkshire	135.9	94.2	58.8
South Wales — Monmouthshire	92.5	88.6	62.0
South Wales — Glamorgan	112.1	77.2	101.6
South Wales — Western	191.1	115.2	139.3
Lancashire	165.1	109.4	98.6
All coal fields	112.2	83.2	70.7
All occupied and retired males	163.5	85.1	49.6

volve exposure to stone dust as well. Mortality records for pulmonary diseases among hewers employed in the three areas of South Wales may be claimed, in so far as they differ from each other, to give some indication as to whether dusts from the three types of coal named exert different pathologic effects.

The standardized mortality figures for these three areas, as compared with certain other coal fields, are shown in Table 4. These figures indicate that English coal miners on an average suffer decidedly less than the standard set by occupied and retired males from respiratory tuberculosis, about the same from pneumonia, but definitely more from bronchitis. When the three South Wales areas are considered, the western area, that reported on by Doctor Jordan and Doctor Clark, is found with figures for each of the diseases not only above those for the other two areas, but above those for all the other fields, and for occupied and retired males, the excess being greatest for bronchitis.

Table 5 gives for these respiratory diseases mortality rates per 100,000 living at various age periods which occurred during the years 1921 to 1923 among coal hewers and getters in the three districts of the South Wales coal field.

An excess of bronchitis, when compared with that experienced by all occupied and retired males taken as a

TABLE 5.—MORTALITY FROM RESPIRATORY DISEASES AT CERTAIN AGE PERIODS PER 100,000 LIVING, AMONG SOUTH WALES COAL HEWERS, 1921 TO 1923

COAL FIELD	AGE PERIOD							
	16–	20–	25–	35–	45–	55–	65–	75+
Bronchitis								
Monmouthshire	0	5	0	20	74	255	1,235	3,053
Glamorgan	0	2	3	16	83	508	1,304	3,542
Western[1]	0	0	0	24	59	789	4,138	5,936
All occupied and retired males	1	3	6	20	56	191	509	1,771
Pneumonia								
Monmouthshire	20	54	17	73	94	223	363	339
Glamorgan	24	39	33	55	97	160	333	459
Western[1]	16	15	44	47	137	368	460	228
All occupied and retired males	21	28	40	72	103	170	276	472
Respiratory Tuberculosis								
Monmouthshire	24	87	90	78	67	112	0	0
Glamorgan	58	84	65	106	119	160	194	66
Western[1]	32	201	158	119	254	158	0	0
All occupied and retired males	69	136	133	160	166	150	114	64

[1] Brecknockshire, Carmarthenshire, Pembrokeshire.

standard, is found among coal hewers aged 45 years and over. This excess is most pronounced in the western group, while the Glamorgan hewer suffers more than his colleague in Monmouth from this cause of death.

Coal hewers of the western group experience an excess death rate from pneumonia at ages 45 to 75. An excess for the Glamorgan and Monmouth hewers is present only at ages 65 to 75.

Although, as is usual for coal miners, the three groups of coal hewers experience no excessive death rate from respiratory tuberculosis, a slight excess is present for the western hewers.

In the absence of any other contributing influence, the trend of these records would support a contention that occupational exposure to dust from anthracite coal mining exerts a definitely injurious effect on the lungs, which increases with age, and expresses itself particularly in mortality from bronchitis and to a less extent in mortality from pneumonia and from respiratory tuberculosis. Dust of mining in bituminous and semibituminous coal does not appear to exert this influence to the same degree, although some undue mortality in late life from bronchitis is associated with it.

The work of the Teams was greatly assisted by information as to geologic and other features in the mines concerned kindly furnished by Captain J. Macleod Carey, Mr. T. Ashley, and Mr. P. T. Jenkins of His Majesty's Mining Inspectorate, and by Mr. E. T. Rees of the Parc and Dare Collieries. To these gentlemen, and also to the officers of the mines concerned, the Association is indebted for invaluable help.

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TEAM REPORT NO. 1

REPORT ON INDUSTRIALLY HEALTHY HEWERS OF STEAM COAL

A. Brownlee, E. Folliott, J. C. Gilchrist, and R. M. Hiley

Colliery Conditions

THE environment of the two collieries in which the men had been employed was as follows: Lower coal measures were worked, consisting of seams of coal with interstratified shales and some few beds of sandstone. The type of coal was sub-meta-bituminous and orthocarbonaceous, giving on analysis:

	%
Carbon	89.0–92.0
Hydrogen	4.2– 4.9
Oxygen	2.0– 4.0
Nitrogen	1.2 (av.)
Sulphur	0.3– 1.0
Volatile matter	13.0–20.0 [1]
Fixed carbon	70.0–80.0 [1]

[1] Ash free, dry basis.

The average composition of dust was found to be: (*a*) from floors, 65 to 70 per cent. stone dust and 30 to 35 per cent. coal dust; and (*b*) from roof and sides, 75 to 85 per cent. stone dust and 15 to 25 per cent. coal dust. But hewers are only exposed to risk of inhaling such dust when passing along the roads to and from their work. The stone dust is definitely placed along the roads to prevent the passage of an explosive wave.

The average temperature of the workings throughout the two pits was:

	Dry Bulb °F.	*Wet Bulb* °F.	*Humidity* %
Pit 1	72.5	70.3	82–94
Pit 2	65.7	63.6	90

The ventilation at both pits was good.

Physical Records

Forty-eight apparently healthy hewers were chosen for study. Their ages ranged from 33 to 65 years, averaging 50 years; six men were under 40 years, and five were 60 years or over.

These men had worked underground on an average 34.1 years; the periods ranged from 17 to 54 years. Five had worked for less than 25 years, and seven for 45 years and over. Only seven of the men had begun their work over age 20; and of these, six had started work under age 22. Twenty-one were between ages 14 and 20 at commencement, and twenty were under age 14, one of whom was only aged 10.

Ten men had done farm work for seven years or less before going underground. All the men were hewers of coal, working at the face. Twenty-one of them, however, were found to have done various other forms of colliery work; and these are dealt with as a separate group.

The average standing height without boots was found to be $65\frac{1}{2}$ inches. The average weight in shirt and trousers (forty-seven men) was $132\frac{3}{4}$ pounds. The average chest measurement at full inspiration was 36.2 inches, and at full expiration 34.5 inches, giving a difference of 1.7 inches. Interest attaches to considering these physical data according to age. Here the miners may be divided into three

groups: one containing fourteen men under 45 years of age, with an average age of 40 years; a second containing sixteen men aged from 45 up to 55 years, with an average age of 49.7 years; and a third containing eighteen men aged 55 years or over, with an average age of 58.8 years. Years

TABLE 1.—PHYSICAL DATA IN RELATION TO AGE GROUPS

AGE GROUP	PERIOD UNDERGROUND	HEIGHT	WEIGHT	CHEST EXPANSION
yrs.	*yrs.*	*in.*	*lbs.*	*in.*
Under 45	28.5	65.7	131.1	2.07
45–55	32.6	65.5	132.2	1.75
55 and over	41.2	65.3	136.0	1.50

underground naturally increased with age; height slightly diminished; weight increased; and chest expansion became less (see Table 1).

Radiographs of Chests

The chest of each hewer was radiographed, and the films were carefully and repeatedly examined. Division into six classes according to the general characteristics of each film was found possible:

Class A.—No noticeable abnormality existed in twenty-two films. But among these in one case there was evidence of old trauma; in another, with no general characteristics, the film was heavy; and in two others slight arborization was noted, but within normal limits. In some of the films the existence of very faint mottling was suspected; the observers felt, however, that the appearance should be disregarded, as possibly being an artifact.

Class B.—Unusually definite arborization was present in two cases.

Class C.—Unusual mottling existed in nineteen cases which may be subdivided into: (1) seven cases showing fine mottling, which in one case was unilateral, while one other showed in addition thickened pleura; (2) three cases showing medium mottling, which in one case was unilateral; and (3) nine cases showing coarse mottling.

Class D.—Signs of old pleurisy appeared in three cases.

Class E.—One case exhibited signs of early pulmonary tuberculosis.

Class F.—One case displayed a honeycomb appearance which could not be classified.

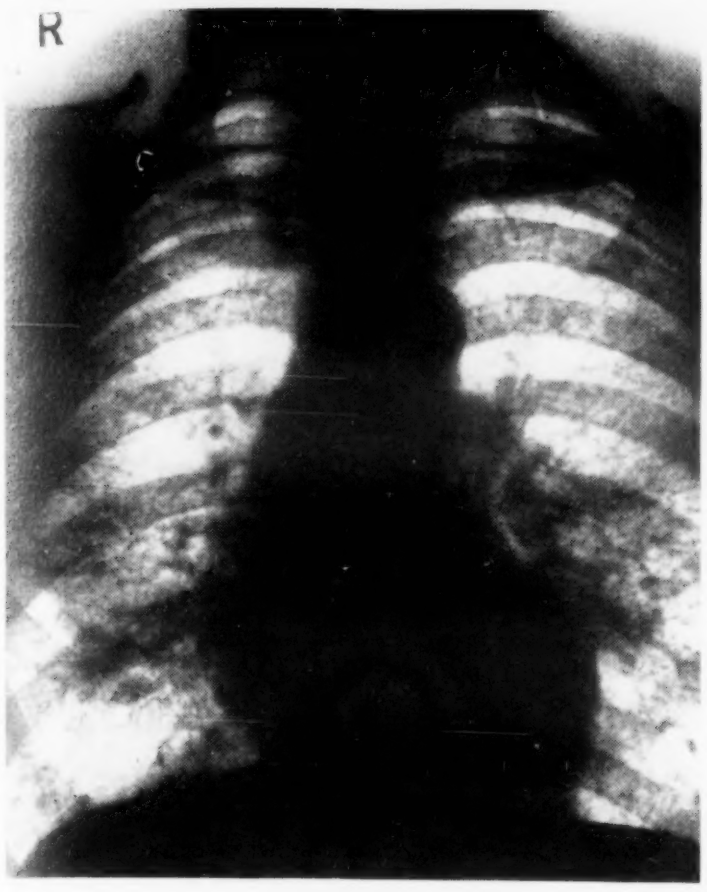
When the films thus classified are distributed according to age groups, a definite increase in the proportion of radiographs showing abnormal shadows is found to go with increase in age (see Table 2). Abnormalities are present in 35.7 per cent. of the youngest

TABLE 2.—RADIOGRAPHIC APPEARANCES IN RELATION TO AGE GROUPS

AGE GROUP	RADIOGRAPH CLASS					
	A	B	C	D	E	F
yrs.						
Under 45	9	1	3	0	1	0
45–55	9	0	5	2	0	0
55 and over	4	1	11	1	0	1

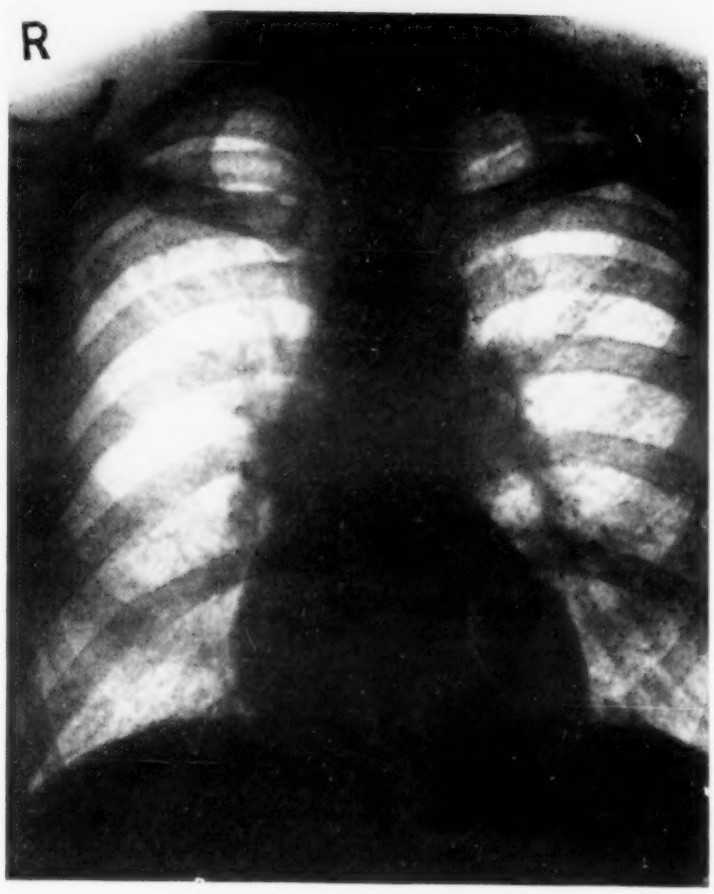
TABLE 3.—RADIOGRAPHIC APPEARANCES IN RELATION TO UNDERGROUND GROUPS

UNDERGROUND GROUP	RADIOGRAPH CLASS					
	A	B	C	D	E	F
yrs.						
Less than 30	11	1	3	1	1	0
30–40	7	1	7	0	0	0
40 and over	4	0	9	2	0	1



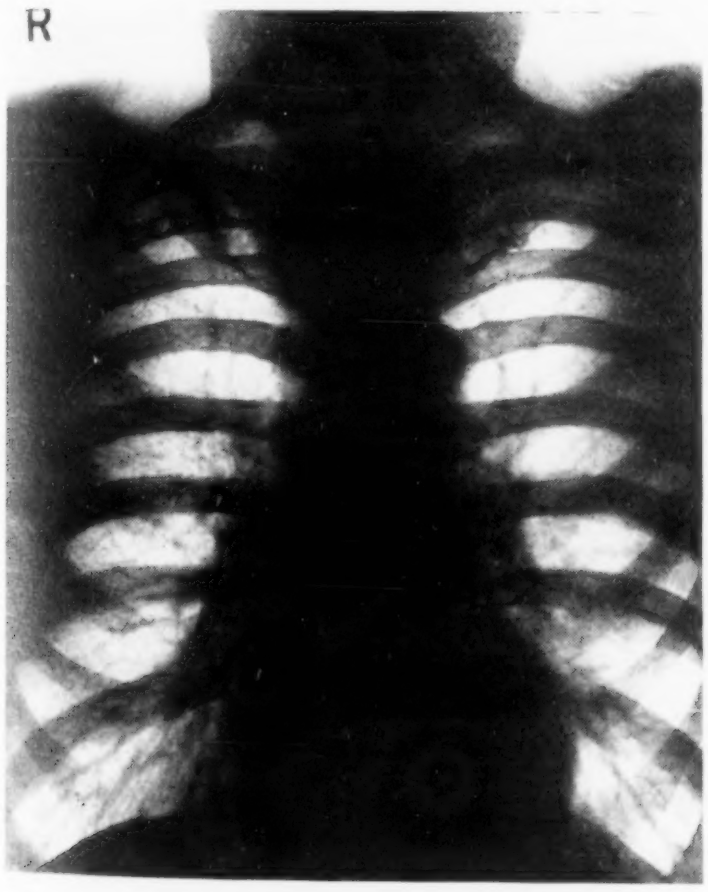
J. E., aged 56. Underground 36 years. Height 66 inches; weight 141½ pounds; chest 38½–37½ inches.

Coarse mottling. Emphysematous chest with hypertrophied heart.



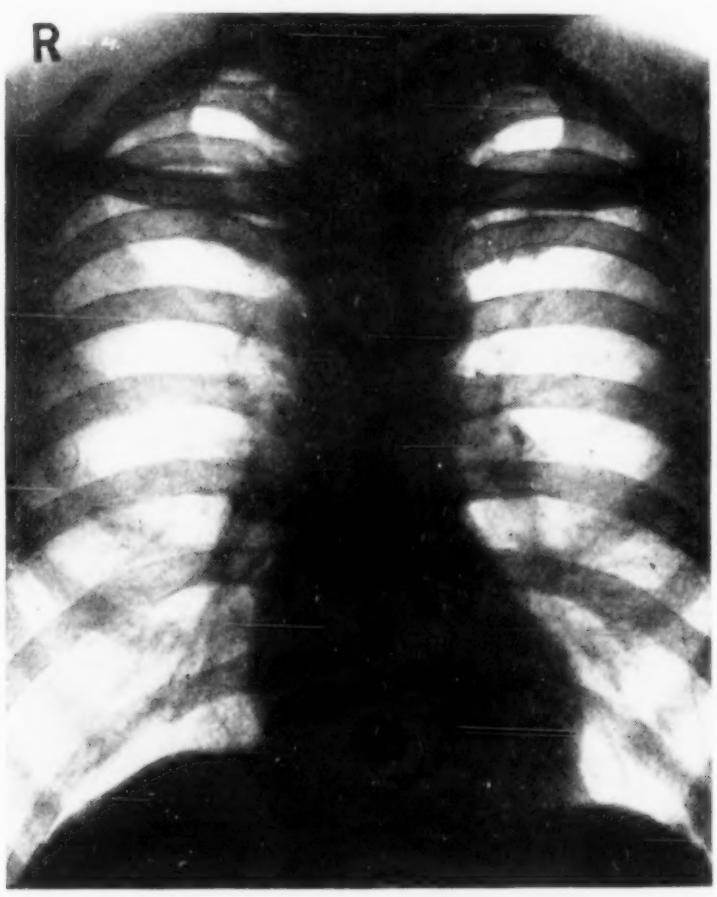
F. A., aged 44. Underground 26 years; 2 years with coal cutter. Height 65¾ inches; weight 137½ pounds; chest 37¾–35 inches.

Fine mottling.



W. J. D., aged 44. Underground 25 years. ight 63½ inches; weight 126 pounds; chest –32½ inches.

Arborization.



D. J. M., aged 48. Underground 29 years; 3 years as repairer. Height 64½ inches; weight 126 pounds; chest 35–32½ inches.

As nearly a normal radiograph of chest as could be seen.

Radiographs of workers in sub-meta-bituminous and orthocarbonaceous coal.

age group, in 43.8 per cent. of the middle age group, but in 77.8 per cent. of the oldest age group.

The miners may also be divided into three groups, according to years underground: (*a*) containing seventeen men with less than 30 years underground, and an average of 24.9 years; (*b*) containing fifteen men with 30 years but less than 40 years underground, and an average of 33.7 years; and (*c*) containing sixteen men with 40 years or over underground, and an average of 44.6 years.

When the films are distributed according to underground groups, the same tendency for abnormal shadow to increase with years is present (Table 3). Here abnormalities occur in 35.3 per cent. of those employed for the fewest years, in 53.3 per cent. of those in the middle group, and in 75 per cent. of those employed longest. But there is a considerable overlapping with the age grouping, since the maximum and minimum ages in group *a* were respectively 50 and 33, in group *b* 58 and 42, and in group *c* 65 and 52.

Further study by grading the radiograph classes according to the existence

TABLE 4.—RADIOGRAPHIC APPEARANCES IN RELATION TO PHYSICAL DATA

RADIOGRAPH CLASS	AGE	PERIOD UNDERGROUND	HEIGHT	WEIGHT	CHEST EXPANSION
	yrs.	*yrs.*	*in.*	*lbs.*	*in.*
Class A	46.7	30.4	66.4	134.0	1.9
Class C (1) and (2)	51.5	35.2	64.8	132.5	1.7
Class C (2) and (3)	55.3	38.3	64.4	131.4	1.3

TABLE 5.—OTHER OCCUPATIONS OF MINERS WITH INTERCURRENT WORK

NO. OF MINERS	OCCUPATION	LENGTH OF TIME
3	haulier and rider	5, 4, 2 yrs.
1	doorboy	5 yrs.
4	repairer	4, 3, 2, 1 yrs.
2	occasional dusting	4 yrs. ago each.
3	conveyor	5 yrs., 2 yrs., 4 mos.
1	coal puncher	not stated (a short while).
3	coal cutter	2 yrs., 9 mos., 9 mos.
1	repairer laborer	6 yrs. 2 yrs.
1	repairer laborer	2½ yrs. 6 mos.
1	laborer conveyor	3 yrs. few mos.
1	repairer haulier and rider conveyor	2 yrs. 2 yrs. 1 yr.

of especially significant shadows gives the average findings presented in Table 4. Here is shown in another way the association of abnormal shadows with increased age and years underground, and with diminished height and chest expansion; but although it has been shown previously that average weight increases with age, here is evident a diminished average weight associated with an increase in abnormal shadows—even though the average ages increase with the shadows.

Miners with Intercurrent Work

This group of twenty-one men had followed other occupations as well as hewing (see Table 5). When their films were separated from the others and carefully studied, the distribution appeared to be quite haphazard, with the exception of the fact that all three men who had worked at coal cutting had abnormal radiographs. Nevertheless, there is some excess of abnormal X-ray appearances in this group as compared with the other twenty-seven men who had been hewers only (Table 6).

TABLE 6.—COMPARISON OF RADIOGRAPHIC APPEARANCES IN HEWERS ONLY AND IN HEWERS WITH OTHER WORK

MINING GROUP	RADIOGRAPH CLASS					
	A	B	C	D	E	F
Hewers only.....	15	1	9	2	0	0
Hewers with other work as well.....	7	1	10	1	1	1

Conclusions

In this series of 48 coal hewers, abnormal X-ray appearances are found to be present in 26. The appearances are generalized in 18 out of these 26, unilateral but extending through a large area in 3, and more localized in 4, while 1 case was not classified.

The abnormal appearances are shown to be associated with high average age, perhaps still more with a high average of underground years, and definitely with a low average height and chest expansion. A noticeable point is that the average weight of the group in which abnormal shadows are densest, is lighter than the general average, in spite of the high average age.

These facts point strongly toward the conclusion that the abnormal X-ray appearances found, are associated with more physical deterioration than is produced by the passage of time or the prolongation of underground life alone.

TEAM REPORT NO. 2

REPORT FROM THE CEFN MABLY GROUP ON 41 HEALTHY MINERS FROM THE NINE MILE POINT AND THE LLANBRADACH COLLIERIES

W. Davies, A. Carveth Johnson, and J. L. Thomas

Colliery Conditions

THE collieries concerned in this part of the investigation are situated in adjacent valleys; the Nine Mile Point Colliery is in the Western Valley of Monmouthshire, and the Llanbradach Colliery in the Rhymney Valley which is on the eastern side of Glamorganshire and bordering on the county of Monmouth.

The geologic formation of Llanbradach Colliery, which does not differ very materially from that of the Nine Mile Point Colliery, is as follows:

4-Foot Seam

	ft./in.
Clift top.	
Clod	0/7
Coal	2/0
Stone	0/1
Coal	1/8
Rashings	0/2
Coal	1/9
Strong fire clay bottom.	

The miners were selected by their own representative who had an intimate knowledge of their industrial history. The majority of the men examined—namely, thirty-one—were working in the 4-foot seam at Llanbradach. The coal from this seam is classed as semibituminous, as is also the coal in the Nine Mile Point Colliery. It is composed of 5.8 per cent. ash, 24 per cent. volatile matter, and 70.2 per cent. fixed carbon, etc.

The chemical composition of the shale dust taken from a clift above the 6-foot seam and at first used for stone dusting is:

		%	
Total volatile	CO_2	3.94	900°C.
	H_2O	0.44	
Carbonaceous matter		5.20	
SiO_2 (combined)		31.96	
SiO_2 (free)		23.10	
Al_2O_3, Fe_2O_3		29.98	
CaO		2.73	
MgO		0.65	
Alkalies		2.00	
		100.00	

Latterly, however, this dust has been mixed with fuller's earth or with carbonate of lime. It is proposed, in the future, to use a mixture of carbonate of lime and lime dust only, omitting the shale dust.

The following readings of temperature, taken on the same day, indicate the average temperature of the workings throughout:

	Wet Bulb °F.	*Dry Bulb* °F.
Intake airway	55.0	56.5
Coal face, intake end	65.0	67.0
Coal face, return end	66.5	69.0
Main return airway, near pit	68.5	71.0

The surface temperature, taken in the fan house, was 74°F. and the barometric pressure 29.19. The workings are well ventilated and a total of 370,000 cubic feet of air per minute is circulated.

In both the Llanbradach and the Nine Mile Point Collieries the lighting is by safety lamp; no naked light is used.

The method of working the coal in these collieries is that known as long-wall. In this system, no pillars of coal are left to support the roof, all the coal being extracted in one continuous line called the face; the space behind this face is called the goaf or gob where stone walls are built and rubbish is packed, on to which the roof subsides behind the hewers. There is usually plenty of stone and rubbish available for packing from the roadways. This method of working the coal enables the hewer to take advantage of the roof weight in working the mineral, thus making the use of explosives unnecessary; also, it greatly simplifies ventilation, which is generally good in the working face.

The hewer, in the collieries investigated, is called upon to do other work than the getting of the coal; he is responsible for the packing of the gob, and also for the maintaining of sufficient height for men and horses on his roadway. The subsidence of the roof on the gob makes it necessary for him either to rip the roof or to cut the floor of the roadway. Generally it is the roof which is ripped, and as much as possible of this is done without the aid of explosives; but the hewer has often to bore holes in the roof in order to get the ripping done. Thus all hewers are called upon to do a certain amount of hard ground work, and are, therefore, exposed to stone dust.

Physical Records

The forty-one men examined all stated that they did the repair work on their own roads. Twenty-two had done work other than the ordinary work of the hewer: six had done hard ground work, the shortest time being 3 months, and the longest 5 years; eight had worked as hauliers for periods ranging from 1 year to 7 years; two had been repairers for 2 years and $3\frac{1}{2}$ years, respectively; one had worked as a haulier for 5 years and for another 5 years as a laborer; one had worked on hard ground for 6 months and as a haulier for 2 years; one had spent 6 years in the lead mines and 3 years on hard ground; one had been a stone quarryman for 3 years; one a farmer for 2 years; and another a blacksmith for 5 years.

The average age of the men was $42\frac{1}{2}$ years; the youngest man was 28 years of age and the oldest 62 years. The average number of years spent underground (underground age) was 28, the range being from 14 to 49 years. Sixteen men had worked for less than 25 years, and three men for 45 years and over. All the men had begun mining at an early age; twenty-six were between 14 and 18 years and fifteen were under 14, three being 10 years of age.

Their average standing height without boots was 66 inches; the maximum was $70\frac{1}{4}$ inches, and the minimum 60 inches. The average weight in trousers was 136 pounds; the maximum and minimum, $166\frac{1}{4}$ and $106\frac{3}{4}$ pounds, respectively. Chest expansion averaged 2 inches, the range being from three-quarters of an inch to $3\frac{1}{4}$ inches.

Dyspnea on exertion was complained of by twelve men, and three men had cough with sputum in the mornings. Eight gave a history of respiratory trouble: three bronchitis, four pleurisy, and one double pneu-

monia. There was a family history of tuberculosis in four cases.

Radiographs of Chests

Each radiograph has been examined and described without reference to the man's occupational or other history. The whole number have been classified on the lines suggested by the South African Miners' Phthisis Medical Bureau, with one additional group—that of "more local fibrosis then usual," (Table 1, No. 3)—as it was found that a group of seven radiographs could not be fitted into the original classification. One radiograph showed evidence of old pulmonary tuberculosis in the left upper lobe, and has not been included in the groups in Table 1. All the hard ground workers except two had generalized mottling throughout the lungs.

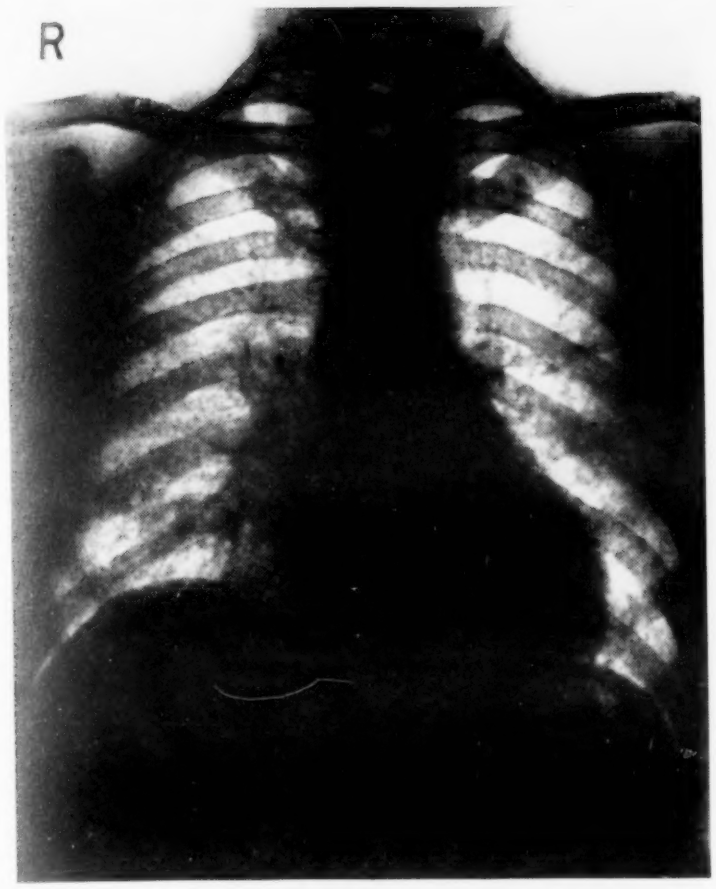
The majority exhibited either normal or hypersthenic type hearts; and only four cases showed the central or asthenic type which is so common in cases of pulmonary tuberculosis.

The anthropometric data have been tabulated according to the amount of fibrosis in the radiographs (Table 2); for this purpose the radiographs have been divided into three classes: 1 and 2 of Table 1 forming class A; 3 and 4, class B; and 5 and 6, class C. The weights have been compared with the body weight in health according to height and age accepted in the medico-actuarial standards of the United States (1912).

The numbers in each class are small, and great caution is necessary in drawing any conclusions from them. There are wide variations in classes A and C: *e.g.*, in the former class, the oldest miner was 52 years of age and had

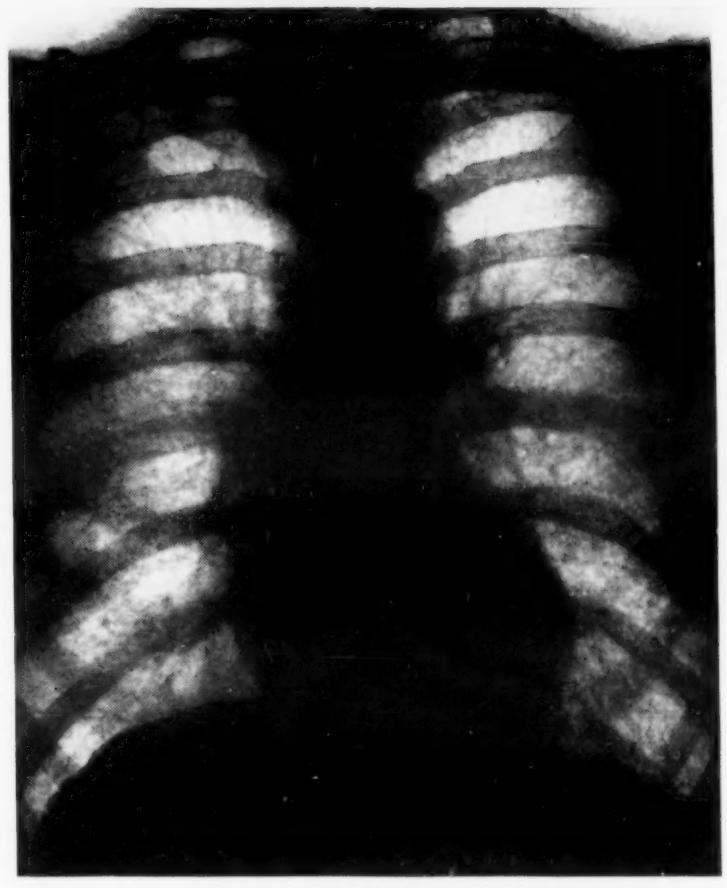
TABLE 1.—CLASSIFICATION OF RADIOGRAPHS

CLASS	RADIOGRAPHIC APPEARANCES	CASES	HEWERS ONLY
1. Normal thorax (N. T.).	Normal shadows.	2	0
2. More fibrosis then usual (M. F. U.).	Increase in the large branch fibrosis.	6	4
3. More local fibrosis then usual (L. F.).	Increase in branch fibrosis with or without mottling, and localized in the lung fields. In our group this increase was apparent more especially toward the right base and the middle transverse zone.	7	5
4. Commencing generalized fibrosis (C. G. F.).	Generalized fine arborization throughout both lung fields with partial small specific mottling, silicotic in type.	4	2
5. Moderate generalized fibrosis (G. F.).	More marked arborization than in the previous group, with symmetrical small mottling throughout both lung fields.	19	8
6. Well-marked fibrosis (E. F.).	Symmetrical generalized medium mottling.	2	0



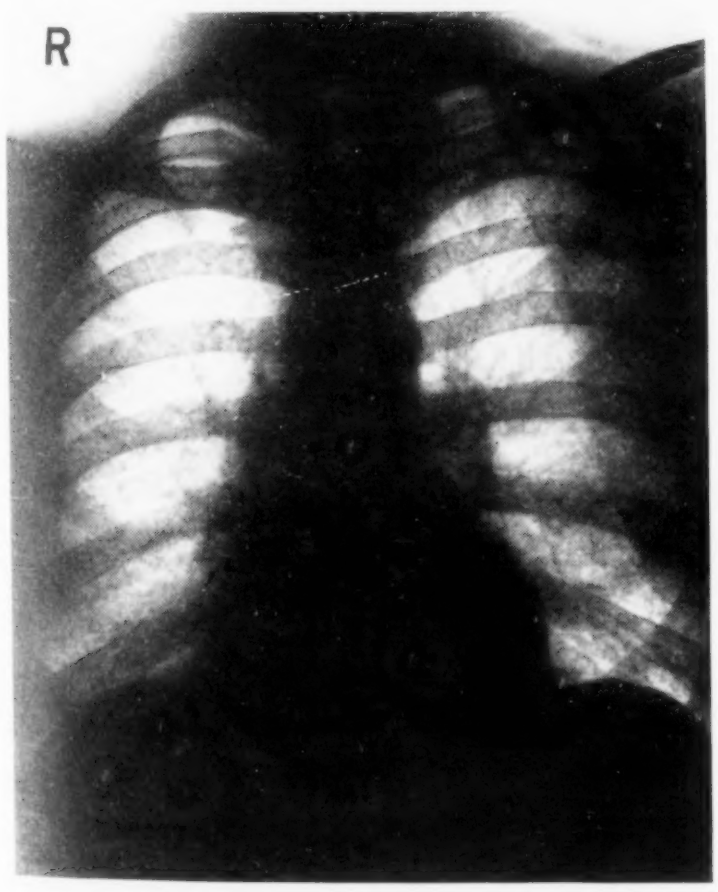
E. E., aged 48. Underground 34 years; haulier 5 years. Height 60 inches; weight 124½ pounds; chest 34½–32¾ inches.

Well-marked fibrosis as evidenced by coarse mottling throughout both lungs but more marked on the right side.



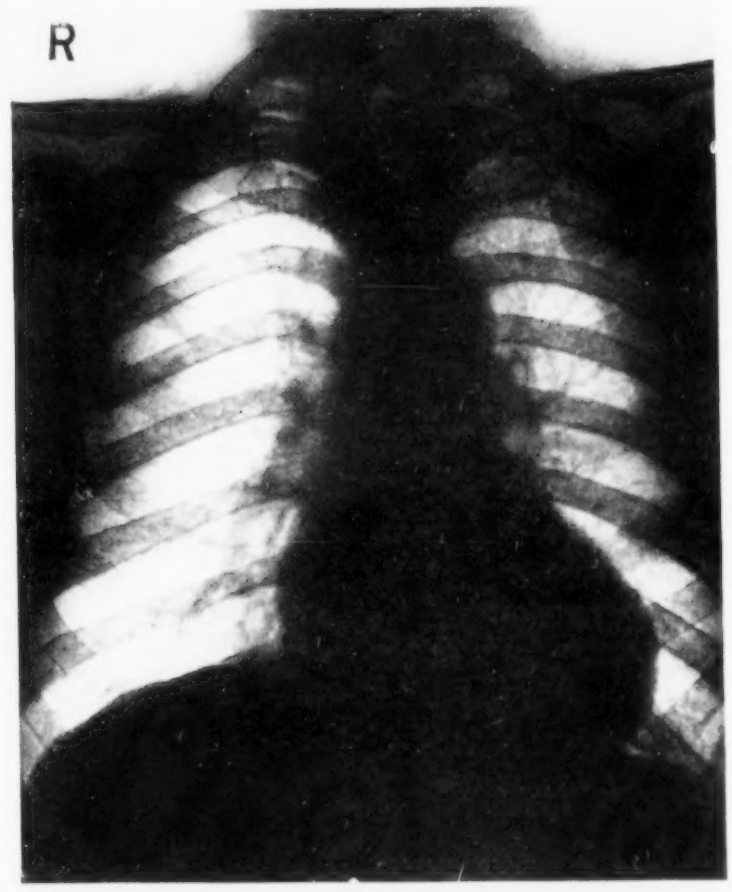
W. P., aged 51. Underground 35 years. Height 70 inches; weight 144½ pounds; chest 37–35 inches.

Moderate generalized fibrosis, accompanied by fine mottling throughout both lungs.



B. C., aged 35. Underground 23 years. Height 70¼ inches; weight 156½ pounds; chest [illegible]–36 inches.

Commencing generalized fibrosis seen as fine arborization with some specific mottling especially at right base.



R. F., aged 52. Underground 38 years. Height 65 inches; weight 142½ pounds; chest 37½–35½ inches.

Normal thorax. It is to be noted that this man had worked for many years underground without apparent lung injury.

Radiographs of workers in semibituminous coal.

worked thirty-eight years underground. His radiograph was regarded as normal, and the lung fields were clearer than those of the younger miners in the same class who had spent much less time underground. On the other hand, class C includes a miner of 28 years of age who had worked only fourteen years underground, and yet whose radiograph showed as much mottling as those of other miners in the same class who had worked forty-nine years underground. However, Table 2 appears to indicate that with increased fibrosis there is a lengthening of the period underground, a diminished chest expansion, and a decreased weight.

The forty-one miners have been divided into three approximately equal groups, according to the amount of time spent underground, as follows: (*a*) fourteen miners who had worked from 14 to 23 years, with an average of 20 years; (*b*) fifteen miners who had worked from 24 to 33 years, with an average of 27 years; and (*c*) twelve miners who had worked 34 years and over, with an average of 40.3 years. The anthropometric details and the radiographic appearances were then tabulated according to these three groups (Tables 3 and 4).

Classified in this way the radiographs show that length of time underground alone does not produce a progressive fibrosis, for group *b* has a smaller number of well-established fibrotic cases than the other two groups; this apparently contradicts Table 2, but we would again emphasize that the numbers in each group are too small to form a basis for reliable conclusions. Still, Table 4 does suggest that there is some other factor, or factors, at work in producing fibrosis.

There are two main factors in the causation to be considered: namely, (1) susceptibility to fibrosis when exposed to dust, and (2) the nature of the dust. With regard to the former, our present state of knowledge does not allow the forming of a definite opinion, but attention is drawn to the two cases previously referred to in this report which lead one to think that such a factor cannot be excluded from consideration.

TABLE 2.—RADIOGRAPHIC APPEARANCES IN RELATION TO ANTHROPOMETRIC DETAILS

NO. OF FILMS	RADIOGRAPH CLASS	AGE	PERIOD UNDERGROUND	HEIGHT	CHEST EXPANSION	WEIGHT	STANDARD WEIGHT
		yrs.	*yrs.*	*in.*	*in.*	*lbs.*	*lbs.*
8	Class A	43.20	21.50	64.94	2.10	141.70	145.0
	Maximum	52.00	38.00	69.50	3.25	153.75	
	Minimum	30.00	16.00	61.50	1.00	127.00	
11	Class B	38.90	24.47	66.50	1.88	144.00	149.0
	Maximum	44.00	30.00	70.25	3.00	166.25	
	Minimum	34.00	20.00	60.00	1.25	127.75	
21	Class C	45.75	32.00	64.50	1.67	134.50	142.5
	Maximum	62.00	49.00	70.25	3.00	159.25	
	Minimum	28.00	14.00	60.00	0.75	106.75	

The miner of 52 years of age who had worked thirty-eight years underground shows no evidence, in his radiograph, of abnormal fibrosis. Either he has an immunity to injury on exposure to dust or he has been lucky enough not to have been exposed to such concentrations of dust as would produce fibrosis. It is hardly credible that he could have worked so long a time underground without often being exposed to high concentrations of dust.

The other case is the young miner of 28 years, who had worked only fourteen years, and whose radiograph exhibited marked fibrosis. Here, either there is an increased susceptibility to fibrosis, or the man has been unfortunate enough to have been constantly exposed to high concentrations of injurious dust. He has done no other work than that of a hewer, and it is reasonable to assume that the conditions under which he has worked are similar to those of other hewers. Yet, his radiograph shows more fibrosis than can be accounted for by duration alone of exposure to dust.

The question whether nasopharyngeal trouble had any effect was considered. Two cases had definite nasal obstruction and their radiographs show definite mottling. In nine other cases there was evidence of some nasopharyngeal catarrh, but their radiographs are scattered indiscriminately throughout the various groups.

The dust to which the hewer is exposed arises from two sources, coal and stone. The composition of the coal dust is a fairly uniform factor, but variations in concentration are common in different parts of the mine. On the other hand, the composition as well as the concentration of the stone dust is variable. It is possible that the silica content of the stone varies considerably in different parts of the mine. Also the amount of hard ground work which the hewer has to

TABLE 3.—ANTHROPOMETRIC DETAILS IN RELATION TO UNDERGROUND GROUPS

UNDERGROUND GROUP	AGE	PERIOD UNDER-GROUND	HEIGHT	CHEST EXPAN-SION	WEIGHT	STANDARD WEIGHT
yrs.	*yrs.*	*yrs.*	*in.*	*in.*	*lbs.*	*lbs.*
14–23	25.35	20.0	67.29	2.33	142.68	150.5
24–33	41.73	27.0	65.59	1.83	140.25	145.0
34 and over	53.83	40.3	65.68	1.89	137.50	149.0

TABLE 4.—RADIOGRAPHIC APPEARANCES IN RELATION TO UNDERGROUND GROUPS

UNDERGROUND GROUP	N.T.	T.B.	M.F.U.	L.F.	C.G.F.	G.F.	E.F.
yrs.							
14–23	1	0	1	3	2	7	0
24–33	0	1	5	4	2	2	1
34 and over	1	0	0	0	0	10	1

do varies with the rate of subsidences of the roof on his roadways. This rate is rarely uniform and is often more rapid in one district than in another in the same seam.

Thus in estimating the cause of fibrosis these variable factors have to be considered, and further research is necessary in evaluating the part played by each.

Conclusions

1. The majority of the men examined show abnormal radiographs, twenty-one out of forty-one exhibiting generalized mottling.

2. The mottling is similar in appearance to that caused by the inhalation of silica dust.

3. The investigation has shown that the hewer is exposed to stone dust as well as to coal dust; in deciding the cause of the abnormal fibrosis, therefore, the possibility of silica dust's being a causative factor cannot be excluded.

TEAM REPORT NO. 3

RADIOGRAPHIC INVESTIGATION OF HEALTHY COAL MINERS CARRIED OUT AT CRAIG-Y-NOS HOSPITAL

N. T. K. Jordan and L. R. Clark

Colliery Conditions

THIS investigation deals with a group of forty-two healthy miners who have worked for a period of fifteen years or more in the coal industry, but who have not worked in hard headings. They may, however, have been liable to occasional work in relation to roof and walls and may, therefore, occasionally have used hand drills. These miners have worked for the greater portion of their time on anthracite coal in the Ystradgynlais and Abercrave Collieries.

The mines are situated at the northern outcrop and the seams are at the base of the coal measures. The inclination of the measures near the outcrop is 7 inches per yard, and where the seams are now worked 2 inches per yard, or almost level. The greatest amount of cover is 220 yards.

Three seams of anthracite coal are worked at each mine, *viz.*, 4-foot, 9-foot (or big vein), and peacock. The analyses of the 4-foot and 9-foot coals are:

	Seam	
	4-Foot	*9-Foot*
	%	%
Carbon	93.00	93.60
Hydrogen	3.50	3.60
Oxygen and nitrogen	3.40	2.54
Volatile matter	6.13	5.83

The analysis of the peacock coal is not available.

The geologic formation of the 4-foot and 9-foot seams is as follows:

4-Foot Seam

	ft./in.
Strong clift.	
Small stone	0/3
Clod	0/0–0/4
Coal	3/7
Cornish	0/6
Hard fire clay	3/0–4/0

9-Foot Seam

	ft./in.
Clift.	
Clod	0/0–0/6
Coal	3/6–4/6
Parting coal	2/2–2/6
Brass natured band	0/½–0/4
Coal	2/0
Rashings	1/0
Inferior coal	0/3

The peacock seam is not essentially different from the 4-foot seam.

Hygrometer readings taken 100 yards from the first working place in each seam are:

	Wet Bulb °F.	*Dry Bulb °F.*
Abercrave:		
4-foot seam	54	60.0
9-foot seam	57	60.0
Peacock seam	59	62.0
Surface	54	58.0
International:		
4-foot seam	59	59.5
9-foot seam	55	53.5
Peacock seam	56	57.0
Surface	54	57.0

The quantity of air passing is as follows:

	Main Intake	*100 Yards from First Working Place*
Abercrave:	*cu. ft. per min.*	
4-foot seam	31,240	2,970 2,800
9-foot seam	7,290	2,870
Peacock seam	.....	3,229
International:		
4-foot seam	14,601	6,000
9-foot seam	10,501	3,269
Peacock seam	2,896	2,064

The roads leading to the workings are wet, but where the men work, the faces are fairly dry, and a fair amount of dust is made in getting and filling the coal.

Physical Records

The average age of the forty-two workers examined was 48; the eldest worker was 65, and the youngest 33 (with the exception of three men over 60 years of age, the eldest was 54). The average period worked in coal was thirty-two years, the longest being fifty-seven and the shortest nineteen years.

All the miners considered themselves as fit for work, but in a considerable proportion of the cases there was distinct evidence of varying degrees of ill health not normally to be expected in a similar group of outdoor workers. Only one man complained of shortness of breath, and he had reached the age of 65 years. Most of the workers, however, appeared to have defective air entry, the average chest expansion being $1\frac{1}{4}$ inches; and this is borne out by the vital capacity statistics given in Table 1.

These vital capacity records are based on the standard figures published by Professor Georges Dreyer.[1] The vital capacity, in each case, was measured by means of the spirometer of Boullite of Paris and is expressed in liters and decimals of liters.

Dreyer, in his book of standards, divides persons into three classes, A, B, and C, according to occupation. Class A refers to men, such as army and navy personnel, engaged in work calculated to keep them in good training. Class C refers to men, such as shopkeepers and shoemakers, whose lives are passed in less healthy surroundings. Class B is intermediate between A and C.

[1] Dreyer, G., and Hanson, G. F.: The Assessment of Physical Fitness. London, Cassell & Co., Ltd.; New York, Paul B. Hoeber, 1921.

TABLE 1.—VITAL CAPACITIES

MINER NO.	WEIGHT	WEIGHT CALCULATED FROM TRUNK	VITAL CAPACITY	VITAL CAPACITY CALCULATED FROM WEIGHT		VITAL CAPACITY CALCULATED FROM TRUNK	
				Class A	Class C	Class A	Class C
	st./lb./oz.	*st./lb.o/z.*	*l.*	*l.*	*l.*	*l.*	*l.*
1	11/ 8/ 2	10/ 0/ 0	2.80	4.62	3.94	4.16	3.55
2	11/ 1/14	9/ 0/ 7	3.25	4.47	3.82	3.86	3.30
3	11/ 1/ 8	11/ 2/ 2	3.69	4.47	3.82	4.50	3.84
4	8/ 8/ 3	10/ 6/ 4	2.90	3.72	3.18	4.29	3.66
5	9/ 3/12	12/ 0/ 3	2.91	3.92	3.35	4.74	4.05
6	8/ 9/12	9/ 3/ 6	3.09	3.74	3.19	3.93	3.35
7	9/ 3/ 0	8/10/ 2	2.70	3.92	3.35	3.77	3.22
8	9/ 1/12	9/ 1/14	2.77	3.87	3.31	3.89	3.32
9	9/ 3/12	9/12/ 7	2.84	3.92	3.35	4.12	3.52
10	9/ 6/ 8	8/ 4/ 9	2.63	3.98	3.40	3.64	3.11
11	8/ 8/ 4	9/ 1/14	2.67	3.72	3.12	3.89	3.32
12	9/ 5/ 0	9/12/ 7	2.80	3.96	3.38	4.12	3.52
13	8/ 9/ 8	8/ 7/ 5	2.85	3.74	3.19	3.70	3.16
14	9/ 7/ 4	9/12/ 7	2.50	4.01	3.42	4.12	3.52
15	8/ 9/12	10/ 4/11	2.60	3.74	3.12	4.26	3.63
16	10/11/ 6	10/11/ 3	2.50	4.39	3.75	4.39	3.75
17	9/ 5/13	8/10/ 2	2.79	3.96	3.28	3.77	3.22
18	8/ 5/12	8/ 3/ 3	3.74	3.65	3.12	3.61	3.08
19	10/11/ 8	12/ 0/ 3	4.14	4.31	3.75	4.74	4.05
20	8/ 3/ 6	8/ 4/ 9	2.70	3.61	3.08	3.64	3.11
21	9/ 0/ 0	8/13/ 0	2.60	3.85	3.29	3.83	3.27
22	9/ 3/10	9/ 1/14	3.40	3.92	3.35	3.89	3.32
23	10/10/10	10/ 1/ 9	3.39	4.37	3.73	4.19	3.58
24	8/ 4/ 0	10/ 9/ 8	2.08	3.63	3.10	4.39	3.75
25	8/ 2/ 0	7/ 1/10	2.72	3.58	3.06	3.25	2.78
26	9/11/ 0	10/ 6/ 5	3.62	4.09	3.49	4.29	3.66
27	9/12/12	9/10/14	3.78	4.11	3.51	4.09	3.49
28	10/ 9/ 8	9/ 4/14	2.28	4.35	3.71	3.96	3.38
29	9/ 2/12	9/ 6/ 5	3.25	3.90	3.33	3.99	3.41
30	7/ 2/ 0	8/10/ 2	2.72	3.26	2.78	3.77	3.22
31	8/ 5/12	10/ 6/ 5	1.80	3.65	3.12	4.29	3.66
32	10/ 4/ 0	10/ 4/11	3.76	4.24	3.62	4.26	3.63
33	10/ 3/ 4	8/10/ 2	2.10	4.22	3.66	4.29	3.66
34	8/ 3/ 0	9/ 4/14	2.86	3.61	3.08	3.96	3.38
35	8/ 3/ 6	8/ 7/ 5	3.34	3.61	3.08	3.70	3.16
36	9/ 8/ 4	8/13/ 0	4.15	4.03	3.44	3.83	3.27
37	10/ 4/ 2	9/ 0/ 7	2.66	4.24	3.62	3.86	3.30
38	8/10/13	8/ 7/ 5	2.55	3.76	3.21	3.70	3.16
39	9/ 5/ 8	8/ 3/ 3	3.09	3.96	3.38	3.61	3.08
40	11/ 5/15	9/10/14	3.48	4.56	3.89	4.09	3.49
41	8/ 0/12	9/ 0/ 7	2.32	3.54	3.02	3.86	3.30
42	9/ 6/ 4	8/ 5/15	2.88	3.98	3.40	3.67	3.16
Average..	9/ 5/ 3	9/ 6/ 5	2.95	3.96	3.38	3.99	3.41

Strictly speaking, the coal miner's occupation, involving hard muscular work, should place the workers in class A. We have, however, compared them with both class A and class C, and have found that their vital capacity is considerably below that of class A men except in two cases, and that it is below that of class C men except in eight cases. This is in agreement with the small chest expansion shown previously.

The average vital capacity was 2.95 liters, as compared with 3.96 and 3.38 calculated from average weight for classes A and C, respectively, and 3.99 and 3.41 calculated from average trunk length for A and C.

It will be noted that, in spite of the fact that these men have been engaged in an industry involving healthy muscular work, their vital capacity is markedly reduced below what might be regarded as normal even in workers belonging to Dreyer's C group of occupations. These men had submitted themselves voluntarily for examination. They had no idea of the significance of the vital capacity estimations, and the possibility of any deliberate attempt to record less than their maximum may be eliminated. It seems clear that their very low readings must be caused, like their diminished chest expansions, by some factor in their environment leading to diminution in the movements of the walls of the thoracic cavity and to a lessening of the air entry into the chest.

The weight of the men investigated, as will be seen in Table 1, is in fairly close conformity with the weight as calculated from the trunk length according to Dreyer's standards. When compared, however, with the average weights for age and height accepted as the medico-actuarial standards in the United States (1912), the weights

TABLE 2.—BODY WEIGHT CALCULATED ACCORDING TO HEIGHT AND AGE
(Medico-Actuarial Standards, United States, 1912)

MINER NO.	HEIGHT	AGE	WEIGHT ACCORDING TO AGE AND HEIGHT	ACTUAL WEIGHT
	in.	*yrs.*	*lbs.*	*lbs.*
1	65.8	41	149	162
2	65.1	45	146	156
3	69.0	47	166	155
4	65.0	49	148	120
5	70.2	53	171	130
6	64.4	48	144	122
7	64.1	50	144	129
8	60.6	52	134	128
9	68.3	61	161	130
10	63.0	46	141	132
11	65.4	53	148	124
12	66.3	40	149	131
13	66.25	56	152	121
14	65.2	65	148	133
15	66.2	53	152	122
16	67.6	55	156	151
17	65.6	54	148	132
18	64.5	52	144	132
19	70.5	36	165	151
20	62.2	39	135	115
21	63.9	52	144	126
22	68.4	52	161	129
23	67.0	45	150	150
24	59.8	52	131	116
25	60.6	55	135	114
26	67.6	54	159	137
27	65.8	40	147	139
28	64.0	51	144	149
29	61.4	48	136	128
30	64.4	39	141	100
31	65.5	52	150	117
32	68.2	38	152	144
33	64.3	53	144	143
34	64.4	52	145	115
35	64.5	39	142	115
36	65.2	33	141	134
37	63.9	45	142	144
38	62.2	52	138	123
39	65.5	33	142	131
40	65.3	43	146	160
41	62.4	64	138	113
42	63.4	43	139	132
Total.	....	..	6,158	5,536[1]

[1] Average loss of over 14 lbs. per head as compared with standard weights.

of these miners are definitely below the latter; the individual weights being less than the American standards in all except six persons. Taken as a group, the average individual weight is about 14 pounds less than it should be for a group of males of similar age and height. The actual weights are compared with the United States standards in Table 2.

Here again there appears to be evidence that the general health of these men is, to some extent, reduced below that of the average for males of similar age and height in other occupations, a fact which is in line with the reduced vital capacities above referred to.

Radiographs of Chests

Turning to the radiographic appearances, we find here also certain peculiarities which characterize these anthracite miners as compared, on the one hand, with agricultural workers of similar age and, on the other, with miners in the softer steam coal of the Rhondda Valley and the semibituminous coal of the eastern parts of the South Wales coal field.

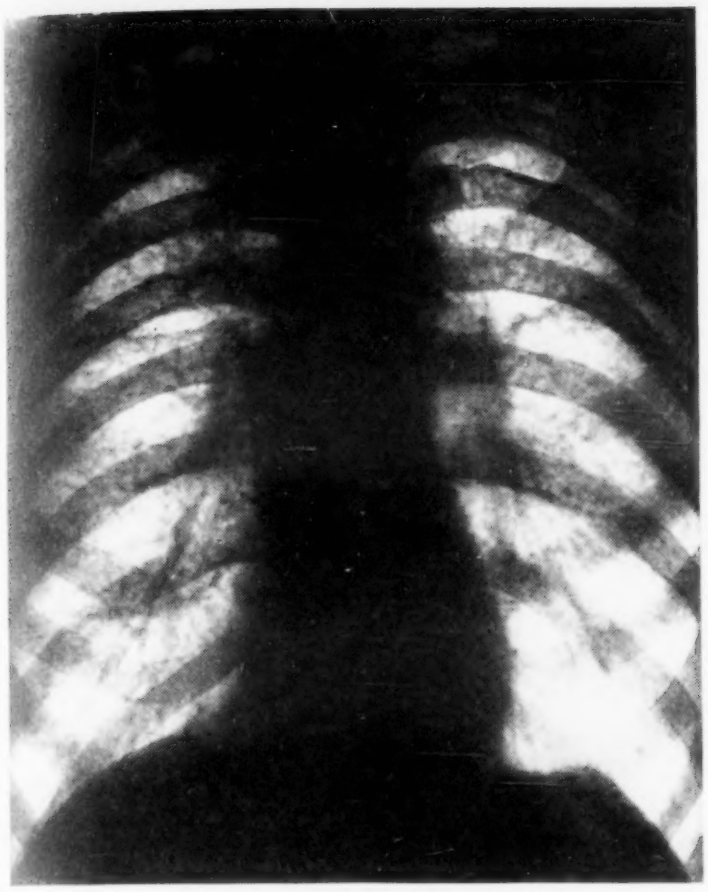
The X-ray changes were assessed according to the system suggested by Professor Cummins, a maximum of 10 marks being allotted to each film under each of the three headings, mottling, arborization, and diffuse shadows. The total marks under each heading for the forty-two films were then added and expressed as a percentage of the possible marks. This method, as was stated in the Introduction, allows of comparison between groups of films from various areas.

The figures for diffuse shadows are too small to be of value in the investigation. With regard to arborization, nothing characteristic was observed in the films as a result of the inhalation of coal dust, and it is probable that the arborization shown in a given film varies considerably according to the radiographic technic. The most significant change found was mottling. This may be coarse or fine, but in the accompanying tables both types have been considered together.

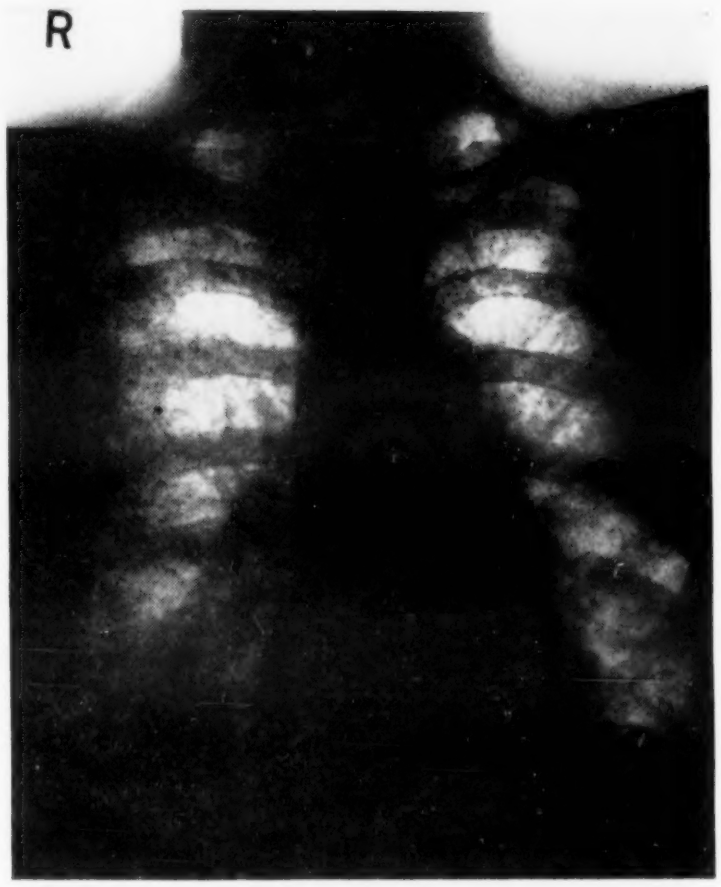
With the exception of two films, all those from the Ystradgynlais and Abercrave area showed marked degrees of mottling; and it is suggestive that these two films were from men aged only 33 and 39, respectively. That the mottling increases with age, and with the period of work in anthracite coal, is shown in Tables 3 and 4. After twenty years' work in the anthracite collieries, a considerable degree of mottling is present in the radiographs and this mottling tends to increase after further years of work. It would also appear that a considerable amount of X-ray change is consistent with a fair degree of working health.

It should be remembered that the Abercrave and Ystradgynlais Collieries are situated in an area in which quarries occur and where the stone contains a very high percentage of silica. The films in many ways suggest the presence of some degree of pulmonary silicosis although the mottling is definitely finer than that observed in typical films from silicotic gold miners in South Africa.

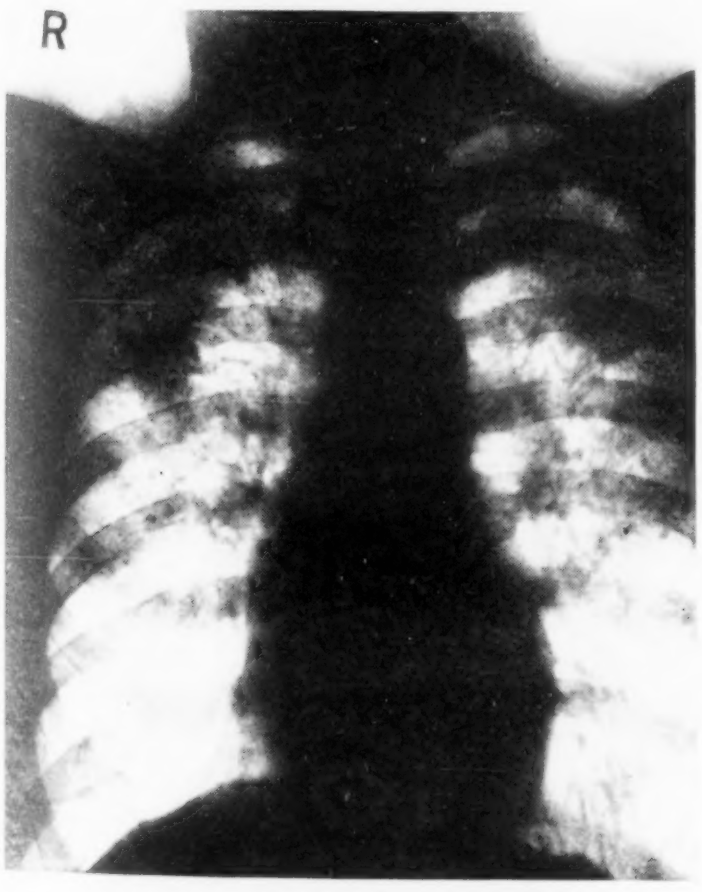
It is difficult to avoid the conclusion that this fine mottling, present to such a marked extent in the films from these anthracite colliers, must depend upon the presence, in the lungs, of a varying amount of nodular fibrosis resulting from exposure to a dust capable of set-



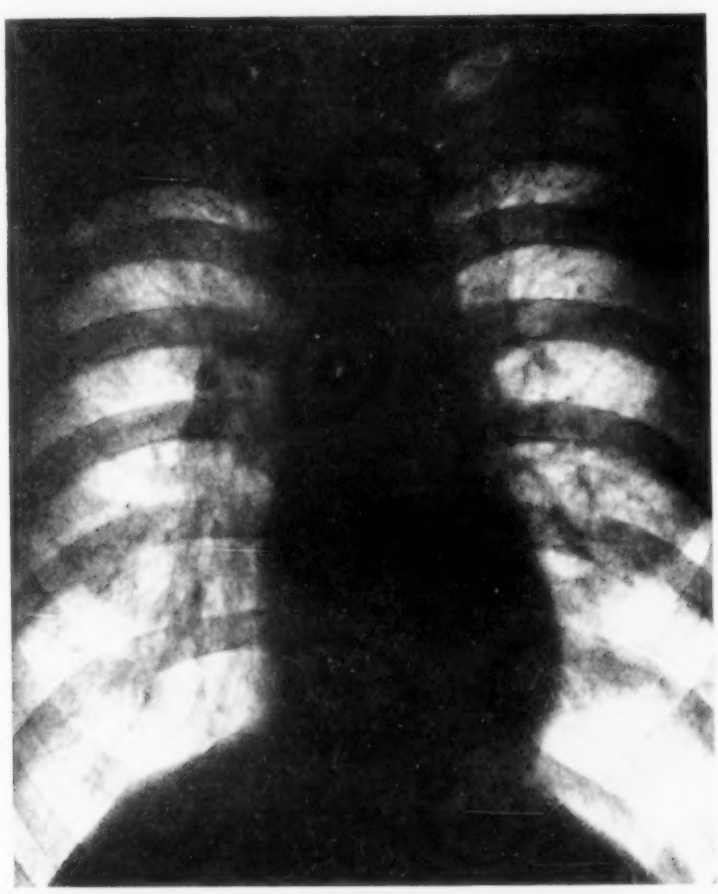
G. M., aged 53. Weight $121\frac{3}{4}$ pounds; chest 36–34 inches; vital capacity 3.09 liters.
Coarse mottling. Tendency to vertical heart.



D. M., aged 64. Chest $33\frac{3}{4}$–$33\frac{1}{4}$ inches; weight and vital capacity not recorded.
Intense fine mottling.



T. W., aged 52. Weight $134\frac{1}{2}$ pounds; chest $35\frac{3}{4}$–$35\frac{1}{4}$ inches; vital capacity 4.15 liters.
Coarse mottling with diffuse shadows; the latter visible below clavicles on each side.



R. M., aged 54. Weight $149\frac{1}{2}$ pounds; chest $39\frac{1}{2}$–37 inches; vital capacity 2.28 liters.
Some arborization with fine mottling. Suggestion of tuberculosis at right apex with calcareous glands at root of right lung. Vertical heart.

Radiographs of workers in anthracite coal.

TABLE 3.—MOTTLING IN RELATION TO AGE GROUPS

AGE GROUP	AVERAGE AGE	AVERAGE PERIOD OF WORK	MOTTLING
yrs.	*yrs.*	*yrs.*	%
30–39 (7 films)	36	20	67
40–49 (13 ")	44	27	70
50–59 (18 ")	52	32	72
60 and over:			
Film 1	61[1]	28	100
Film 2	64[1]	35	100
Film 3	65[1]	57	Heavy diffuse shadows

[1] Actual age.

TABLE 4.—MOTTLING IN RELATION TO YEARS OF WORK

NO. OF CASES	PERIOD OF WORK	MOTTLING
	yrs.	%
7	20 and under	51
19	21–30	81
11	31–40	76
5	41 and over	82

ting up a pneumonokoniosis; and we learn from Professor Cummins that he and Dr. Sladden have found such a condition to exist in the lungs of anthracite colliers dying of intercurrent disease.

It would appear, however, that even well-marked X-ray changes of this type are consistent with a fair degree of health; nor does the pneumonokoniosis causing these abnormal shadows seem to be associated with any marked tendency to the high death rate from pulmonary tuberculosis so constantly observed in the silicosis of the South African gold fields and elsewhere.

There remains the question whether the rather marked tendency to an augmented death rate from bronchitis in the older age groups of coal miners in Breconshire is connected with this pulmonary fibrosis, owing, perhaps, to some element in the dust inhaled by anthracite workers. To the elucidation of the problem, a further radiographic study, directed to sick rather than to healthy miners, appears desirable.

GENERAL CONCLUSIONS

A perusal of these three reports, each compiled separately by a Team of experienced medical men, suggests that certain general conclusions may be drawn in amplification of the conclusions arrived at by the individual Teams.

1. Prolonged exposure to the working conditions incident to coal mining is frequently associated with the gradual development of alterations in the radiographic appearances of the lungs.

2. These alterations are manifest as a fine or coarse mottling throughout the lung fields, the type being comparable with that observed in X-ray films of the lungs of persons exposed to silica dust and to certain other dusts capable of leading to pneumonokoniosis.

3. No significant degree of mottling is to be seen in X-ray control films from agricultural workers of comparable ages and it is, therefore, legitimate to

conclude that the mottling observed in X-ray films from coal miners is due to conditions encountered in the industry, and especially to the inhalation of the dusts suspended in the air of coal mines.

4. The lung alterations above described increase in amount with the duration of employment, but even when present to a marked extent, as seen in X-ray films, they may be quite consistent with working health.

5. The alterations, however, represent a definite impairment of the lung structure and involve an increasing amount of interference with the respiratory efficiency of the lungs as manifested in a diminished vital capacity and such general symptoms as gradual loss of weight and shortness of breath.

6. How far these changes are operative in the production of the respiratory diseases to which South Wales coal miners are liable in late middle age and old age is not yet clear; but the fact that these diseases attain their maximum incidence in the anthracite coal field where the X-ray mottling is found to a greater extent than elsewhere suggests a causal relationship between lung fibrosis and the respiratory conditions common in old coal miners. It is to be noted, however, that the lung fibrosis of South Wales coal miners is not associated with the marked liability to pulmonary tuberculosis known to complicate silicosis of the lungs.

7. It may be added that recent pathologic observations, as yet unpublished, on the lungs of coal miners, carried out at or in conjunction with the Tuberculosis Department of the Welsh National School of Medicine, suggest that the lung opacities appearing as mottling in X-ray films are due to the development of lung fibrosis, and that this fibrosis is associated with an abnormal amount of silica in the lung ash and the retention of excessive coal dust in the lung tissues.

BOOK REVIEW

INTERNATIONALE ÜBERSICHT ÜBER GEWERBEKRANKHEITEN NACH DEN BERICHTEN DER GEWERBEAUFSICHTSBEHÖRDEN DER KULTURLÄNDER ÜBER DIE JAHRE 1920 BIS 1926. By *E. Brezina*, Sektionsrat im Bundesministerium für soziale Verwaltung; Professor an der Techn. Hochschule in Wien. Paper. Pp. 205 with index. Schrift. a. d. Gesamtgeb. d. Gewerbehyg., N. S. No. 24. Berlin: Julius Springer, 1929.

This is a very valuable condensation of the factory inspection reports for the years 1920 to 1926 in what Brezina calls the "Kulturländer," in which unfortunately the United States cannot for his purpose be included. Out of the wealth of this material it seems best to select the less familiar industrial poisons, the more unusual sources of familiar poisons, and some unusual forms of poisoning from well-known agents.

Under the first heading comes cadmium. The English inspectors report two cases occurring in a paint factory from fumes from melting ingots. The symptoms were dryness in the throat, nausea, inclination to vomit, headache, quick pulse, and a deep brown urine. A more puzzling report comes from Germany where cadmium fumes were apparently responsible for illness in men recovering cadmium from the residue left in lithopone production,

for when the fumes were prevented, the cases of illness ceased. At the time these cases appeared, 1923, it was thought that arsine must be responsible but since then animal experiments have shown the harmful effects of cadmium fumes. In 1925, however, five additional cases were reported from what is apparently a different factory also producing lithopone, and these cases are attributed not to cadmium but to arsine. Here five men were severely poisoned and one died after inhaling fumes while precipitating cadmium with zinc dust and dissolving the cadmium powder in hydrochloric acid. It is stated that in the previous year there were ten cases with one death. The process involved the production of nascent hydrogen and arsenic was present in the acid and in the zinc.

In an English manganese works, three cases of poisoning in an early stage were found by examining all the employees. Three more serious cases are reported from Germany from two plants. The first, a man of 33 years who had been employed for five years, had a mask-like face, disturbed speech, loss of power in his hands, difficulty in walking, tendency to retropulsion, attacks of trembling. The other two had been employed only a year and showed uncertainty of gait and slight mask-like change of the face.

A very unusual case of poisoning from barium was reported from a chemical factory in a man who worked twelve days at a mill grinding barium superoxide. He complained to his family of gastric distress from swallowing the dust. On the twelfth day he developed a right-sided paralysis and died the next day. Barium was present in all of the organs. The barium material was found to consist of 44 per cent. barium superoxide and 56 per cent. barium carbonate. The former, which is soluble in water even without acid, is very toxic and is absorbed from the lungs and from the gastro-intestinal tract.

Six cases of nickel carbonyl poisoning with one death were reported in England, being the first to occur in nineteen years. The men were working for two hours repairing a filter near the subliming apparatus.

A case of tobacco blindess in a woman exposed for twenty-five years to tobacco dust is also reported in England. All other possible causes were ruled out.

The acute illness of a German workman who was grinding ferrovanadium was diagnosed as poisoning by ferrovanadic acid. The symptoms were dizziness, vomiting, acid eructations, psychic disturbances of a character not specified, and skin eruption.

Antimony poisoning was reported from Hamburg where some workmen sickened and were incapacitated for ten days, suffering from dyspnea, headache, vomiting, conjunctivitis, and bloody purulent discharge from the nose. They were grinding metallic antimony. In Holland also a case of antimony poisoning is described in a man who broke up large pieces of antimony. A drug house in Germany reported symptoms of poisoning among packers of atropine, veratrin, and strychnine.

Sulphur monochloride is, strangely enough, held responsible for one death in the rubber industry in Germany but no details are given. There is also a report from Austria of a man

inhaling fumes of sulphur monochloride for some time who suffered from jaundice, marked loss of weight, and then sudden paralysis of the legs and of the sphincters of bladder and anus, and slight palsy of the forearm. He recovered after fourteen days. In neither report is any reason given for holding sulphur monochloride responsible for these cases.

Phenylhydrazine caused acute poisoning in a German workman, who was exposed for only a few moments to the fumes from a receptacle. After two hours he complained of severe headache, exhaustion, difficulty in swallowing, and attacks of severe abdominal pain. He recovered after eight days. A short time before, the works chemist had suffered a similar attack without tracing it to its source.

Among the unusual sources of well-known poisons is arsine poisoning in a copper smelter. The man was employed in the copper cement department where copper is precipitated with iron scrap. Galvanized iron scrap was mixed with the other scrap and it is probable that the zinc contained arsenic. The gas was formed when the cement vessel was being emptied and the workman, who was not wearing a mask, was severely poisoned and unfit for work for sixteen days. Two fatal cases occurred in the cleaning of a sulphuric acid tank car, in spite of the fact that the men wore masks and the tank had been flushed repeatedly. Another workman became ill while he was cleaning a wrought iron storage tank which had held 40° Bé. sulphuric acid. The sludge that had collected was driven up into the wash water by means of compressed air and the man dipped it out, a current of fresh air being driven past his face for protection against possible fumes. He had to give up the work after a short time because he felt ill; five days later he died of arsine poisoning, the explanation being that the zinc coating of the galvanized dipper he used contained arsenic.

In a plant producing ferrosilicon where phosphorus-containing cast iron was used instead of phosphorus-free wrought iron, four workmen were poisoned by phosphine in packing the finished product. Fumes of phosphine from an acetylene torch in a Dutch shipyard caused a case of phosphine poisoning, and in a German acetylene production plant a case of mild phosphine poisoning developed in a man who was cleaning out the lime sludge tank. Another report of phosphine poisoning from Holland belongs to the now familiar series of phosphine fume poisoning from a cargo of ferrosilicon. These fumes caused the sickness of the skipper and his three children, the youngest of whom died. The cargo had got soaked with water.

The viscose process of arificial silk manufacture is used in Germany, in Austria, and in Holland, and all these countries report cases of irritation of the eyes with sometimes severe conjunctivitis and burns of the cornea from the hydrogen sulphide which escapes in the spinning department and in the centrifuging. The Germans reduced the cases from 121 per cent. in the first quarter of one year to 19.8 per cent. in the fourth quarter by installing proper fume exhausts. The Austrians reduced the cases from 13.2 per cent. in 1923 to 4.9 per cent. in 1925. Dutch inspectors have found as much as 87 mg. of hydrogen sulphide

in a cubic meter of air. If it can be kept down to 20 mg. they find that there is no complaint. They also find evidence of chronic poisoning, the symptoms of which are very like those of chronic carbon disulphide poisoning—headache, drowsiness, weariness and loss of appetite, emaciation, trembling and twitching of the face, strange dreams, and in one case, a transient psychosis. Cases of hydrogen sulphide poisoning with conjunctivitis and sometimes keratitis are also reported from the Dutch sugar factories. Coins carried in the pockets of the workmen are blackened and paper soaked with lead acetate solution turns black in the air of the workroom. The Germans report poisoning from this gas in the rubber industry, in the production of barium sulphide, and from various sources in the chemical industry. A curious case is reported of a locomotive fireman who died in a few hours from edema of the lungs, attributed to the breathing of hydrogen sulphide and carbon monoxide from brown coal which was packed tightly around the boiler so that it was hot enough to give off these gases.

An unusually severe case of poisoning was caused by the breaking of a glass container of sulphuric acid, which compelled a man to breathe the fumes for fifteen minutes. He developed a severe inflammation of the throat and larynx, and this was followed by carcinoma of the larynx from which he died in a few months. This is from the German report. Several severe cases of acute benzine poisoning are reported from Germany, from England, and from Holland, all from inhaling fumes in cleaning tanks or sopping up spillage or stopping leaks.

Apparently some thirty-three (or forty-one?) new cases of bladder tumor among workers with coal tar derivatives have come to light in Germany during these six years.

Several cases of acute benzol poisoning are reported from Germany occurring in men exposed to heavy fumes. One of these seems to have been a case of unusual susceptibility. A workman entered an empty benzol vessel which had been washed out six times with water. Shortly after, he lost consciousness and although he was carried out immediately, and oxygen was administered, he could not be brought to. Since several plumbers had worked in this receptacle for some days, the employer insisted that benzol could not have been the cause of death; nevertheless, at autopsy considerable amounts of benzol were found in the organs, especially in the brain.—*Alice Hamilton.*